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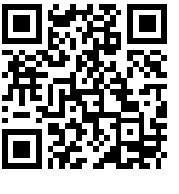

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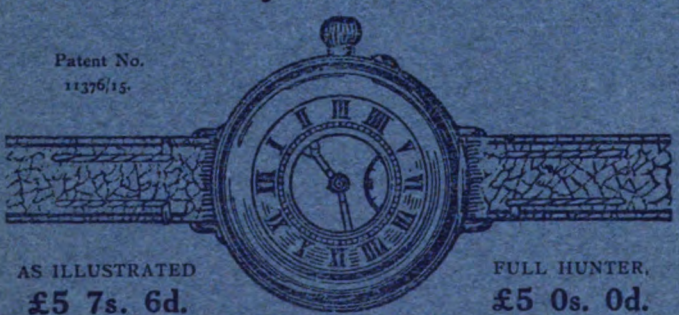

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SURVEY IN FRANCE DURING THE WAR.

(Based on a Lecture given at the S.M.E. on the 10th April, 1919).

By Lieut.-Colonel E. M. Jack, C.M.G., D.S.O., R.E.

The following account of the Survey organization in France during the war will, I hope, be of interest to R.E. officers. The work done was of some importance, and was controlled entirely by R.E. officers; but little is known about it in the Corps.

The article deals in a general way with the main aspects of our work, and is divided as follows:—

I. A brief historical account of the development of Survey units.

II. A description of the organization of a Field Survey Battalion as it existed at the termination of hostilities.

III. An account of the development, from the technical point of view, of the various branches of the work.

I. General History.

The only provision in the original Expeditionary Force for topographical work was as follows. At G.H.Q. there was the Topographical Sub-section of the General Staff, known officially as I.(c), but more commonly as "Maps G.H.Q.", and consisting of one officer (G.S.O.3) and a clerk. On the L. of C. there was one officer and a clerk; and divided between L. of C. and the Army was the Printing Co., R.E. The Printing Co. was organized in four sections; one for G.H.Q., one for L. of C., and two mobile sections for work with Corps (which at that date consisted of two Divisions).

The Topographical Sub-section, or Maps G.H.Q. as it will hereafter be called, was augmented in the first month of the war by one clerk and a box-car. The L. of C. Map Section was increased before the end of 1914 to five clerks and storekeepers, and a map depôt established, first at Abbeville and later at Rouen. The Printing Co., with the exception of a small letter-press printing section which was left on the L. of C., was concentrated wholly at G.H.Q. in September, 1914, the Corps sections having been withdrawn from the Corps, who said they did not require them.

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Towards the end of 1914 the need of better provision for large scale maps became apparent, and advantage was taken of the presence in France of the 1st Ranging Section (consisting of 1 officer and 4 other ranks, all surveyors) to start Survey work in the field.

The ranging section was an R.E. unit which was formed at the Ordnance Survey, Southampton, in response to a demand for some means of identifying hidden targets. The idea was that an aeroplane should, when vertically over the target, let fall a smoke bomb or other easily visible signal. The ranging section, with two theodolite observers at either end of a measured base, would fix the position of the aeroplane at the moment of signalling, and thus the position of the target. The survey part of this scheme was simple, but the part of the aeroplane presented various practical difficulties which were not easily overcome. Finally the development of wireless communication between aeroplane and battery provided a more certain means of identifying targets and the Ranging Section was no longer required.

The section was augmented by 12 topographers obtained from the Ordnance Survey, and others from Field Cos. and other R.E. units in France, and was finally, in April, 1915, attached to Maps G.H.Q. as the 1st Ranging and Survey Section, and undertook survey in the field for the whole Expeditionary Force.

In 1915 armies were formed, and in March of that year a "Maps and Printing Section," consisting of an officer, a small staff, and a detachment of the Printing Co., was formed for each of the two armies then in being.

With extensions of the front the task of survey for the whole Expeditionary Force became too great for one section to carry out; consequently in the autumn of 1915 the personnel of the Ranging and Survey Section was divided into three, forming "Topographical Sections" for the First, Second and the newly formed Third Army.

In the meantime the problem of fixing the positions of enemy batteries had been taken up in various ways, and the system developed was finally incorporated in the Survey organization, on the formation of the Field Survey Cos. in 1916.

Concurrently the system of fixing the positions of enemy guns by recording the sound of their discharge (known as Sound Ranging) was being developed. The first British section was formed in November, 1915.

By the beginning of 1916 survey work had increased to such an extent that a considerable increase in establishment was found necessary, and in February the Topographical Sections were converted to Field Survey Cos. These Cos. included a staff for survey, map compilation and drawing, battery compilation, and printing, as

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well as the Observation Groups and Sound Ranging Sections. The Printing Co. personnel became definitely part of the Field Survey Cos., and ceased to be detachments from the Printing Co.

By the summer of 1916 there were five Field Survey Cos., formed on this model, for the five British armies.

With the continued increase of the British forces, and of the front and area to be dealt with, the Corps began to feel the need of a small organization to provide for its local mapping requirements. Consequently Corps Topographical Sections were authorized in February, 1917. These sections formed a part of the Field Survey Co. of the Army to which the Corps belonged.

As the work of the Survey units expanded it became necessary to make provision for instruction and training. The Experimental Sound Ranging Section was formed in August, 1916, and transferred from the front to G.H.Q. early in 1917. At the same time the nucleus of a workshop for the maintenance of Sound Ranging apparatus was collected. In April, 1917, the School of Instruction for Flash Observation, which had been formed in the 3rd Field Survey Co., was taken over by G.H.Q. To co-ordinate these units and to superintend generally the training and supply of personnel for the Field Survey Cos., the Depôt Field Survey Co. was formed in April, 1917.

No other material change in the organization of the Field Survey units was made, but the continual growth of the work necessitated further increases in establishment, the first of which was authorized in October, 1916.

In September, 1917, authority was given for the conversion of the Companies into Field Survey Battalions, with Lieut.-Colonels in command. Further proposals for enlarging the establishment were made, but the military situation in the early part of 1918 rendered any increase impossible. In the autumn of 1918 the strength of the H.Q. Sections was increased, but at the expense of certain Observation Groups and S.R. Sections which had to be disbanded. This was the situation at the termination of hostilities in November.

In the meantime the establishment of Maps G.H.Q. had been altered and increased to meet the growing needs of the situation. The importance of the work was recognized by the advancement of the officer in charge to G.S.O. 2nd grade in March, 1915; and again, in May, 1917, to G.S.O. 1st grade, with (from June; 1918) the temporary rank of Colonel. The staff was increased in May, 1917, by one G.S.O.3, for map reproduction and supply; and in June, 1918, by the following addition, though with one exception these had been working at G.H.Q. for some months before that date: 1 lieut.-colonel (technical assistant), 2 majors (advisers on Sound Ranging and Flash Observation), 1 captain (personnel) and 1 lieutenant (equipment).

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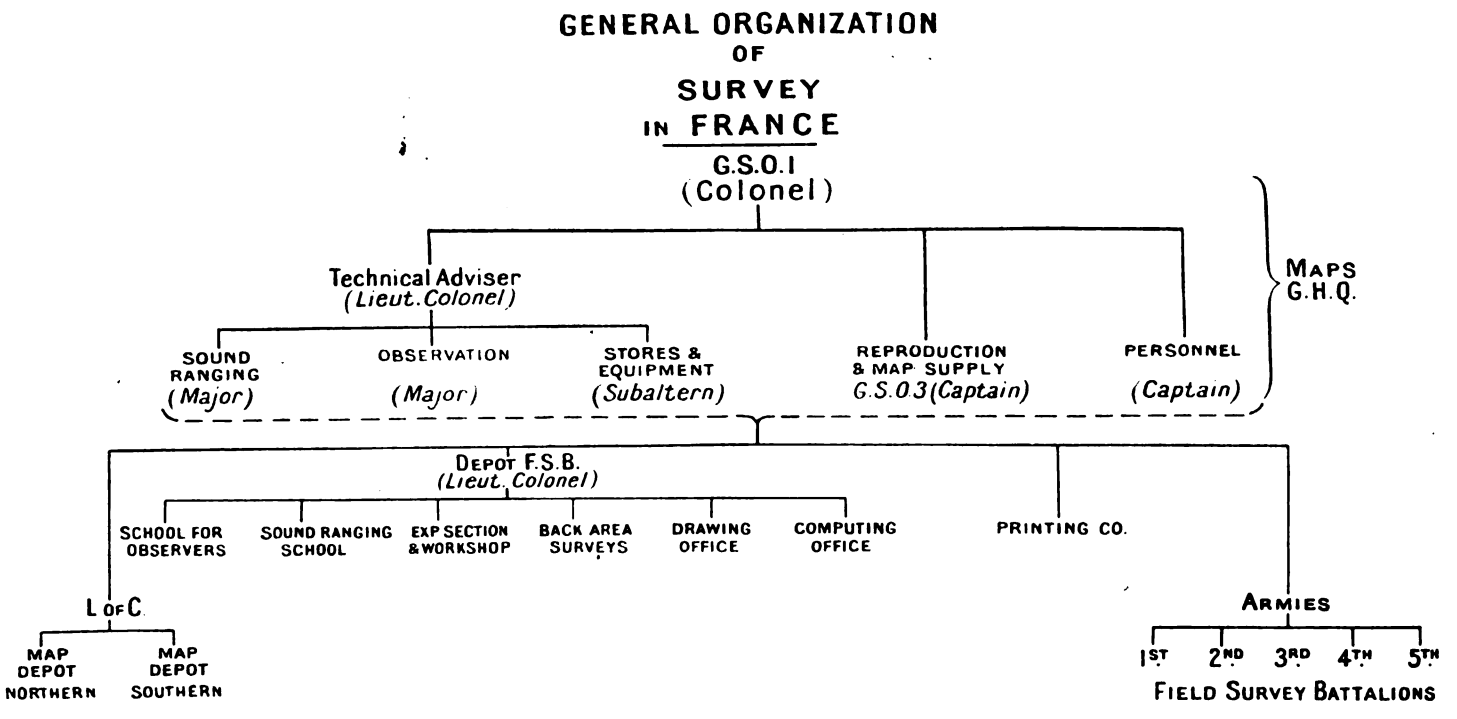

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On the L. of C., the officer in charge, Lieut. (now Major) O. E. Wynne, R.E., having completed the organization of the work, left in November, 1914, and the Base supply was thereafter in charge of a W.O., S.M. Clemons, R.E. A large Base depôt was established at Rouen, with an advanced depôt at Abbeville. Subsequently, on the reorganization of the L. of C. into L. of C. North and South, a depôt for the northern system of supply was formed at Calais, in charge of Q.M.S. Spelman, R.E., while the depôt at Abbeville was enlarged and supplied formations on the southern system. At the same time the depôt at Rouen was abolished.

The Printing Co. at G.H.Q., having originally provided detachments for the armies, and these detachments having been absorbed into the Field Survey Cos. on the formation of the latter, remained as a separate unit responsible for letter press printing and map reproduction for G.H.Q. Its establishment was increased on two occasions. On the formation of the Depôt Field Survey Co. in April, 1917, the Printing Co. was absorbed into that unit, becoming a Printing "Section"; but on the formation of the Depôt Field Survey Batt. (October, 1917) it was restored to its former status of an independent unit.

Besides the survey units in France there were certain others that were formed mainly on our model, and for which Observation Groups and S.R. Sections were supplied from France. On the dispatch of British forces to Italy a nucleus of survey personnel was sent, which later was formed into the 6th F.S. Co. In Egypt the 7th F.S. Co. was formed, and in Salonika the 8th F.S. Co.

The following officers commanded the Survey units up to the termination of hostilities.

1st Ranging & Survey Section..	Major H. St.J. L. Winterbotham, R.E.
1st Army Maps & Printing Section	Lieut. C. Romer, R.E.
2nd ,, ,, ,,	Lieut. B. Lightfoot, R.E.
1st Army Topographical Section	Capt. W. H. Tapp, Queen's Bays.
2nd ,, ,, ,,	Major C. S. Reid, R.E.
3rd ,, ,, ,,	Major H. St. J. L. Winterbotham, R.E.
1st F.S. Co. and Batt.	Lt.-Col. H. Wood, R.E., succeeded on transfer to Salonika by Lt.-Col. B. H. Wilbraham, R.E.
2nd ,, ,, ...	Lt.-Col. C. S. Reid, R.E.

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3rd F.S. Co. and Batt.	Lt.-Col. H. St. J. L. Winterbotham, R.E., succeeded on transfer to G.H.Q., by Lt.-Col. B. F. E. Keeling, R.E.
4th ,, ,, ...	Lt.-Col. M. N. MacLeod, R.E.
5th ,, ,, ...	Lt.-Col. B. F. E. Keeling, R.E., succeeded, on being wounded, by Lt.-Col. F. B. Legh, R.E.
Depôt F.S. Co. and Batt. ...	Lt.-Col. B. F. E. Keeling, R.E., succeeded by Lt.-Col. L. N. F. I. King, R.E.
Printing Co.	Capt. B. H. Wilbraham, R.E., Capt. E. E. Field, R.E., Major W. Stanford, R.F.A., Capt. T. Curr, A. & S. Hrs.
6th F.S. Co.. (Italy)	Major C. S. Reid, R.E., succeeded by Major G. F. Jones, R.E.
7th F.S. Co. (Egypt)	Major W. J. Maule, R.E.
8th F.S. Co. (Salonika)	Lt.-Col. H. Wood, R.E.

Lt.-Col. Jack was in charge of Maps G.H.Q. throughout the war, and on the termination of hostilities his staff was as follows :

Technical Assistant	Lt.-Col. H. St. J. L. Winterbotham, R.E.
Adviser on Sound Ranging ...	Major W. L. Bragg, Leic. R.H.A.
,, Flash Observation ...	Major H. H. Hemming, R.F.A.
Officer i/c Map Supply	Capt. E. E. Field, R.E.
,, Personnel	Capt. G. Carlyle, R.E.
,, Equipment	Lieut. G. Allingham, R.E.

II. Organization of the Field Survey Battalion.

The Field Survey Batt. was organized as a H.Q. Section, and a variable number of Corps Topographical Sections, Sound Ranging Sections and Observation Groups.

The numbers given below are those on the W.E. Actually they were nearly always exceeded in practice by the addition of supernumeraries. The organization of duties differed slightly in different battalions.

The H.Q. Section (13 officers and 175 other ranks) included staffs for survey, mapping, printing, map supply and battery compilation ; besides the usual work of discipline and administration required for a military unit.

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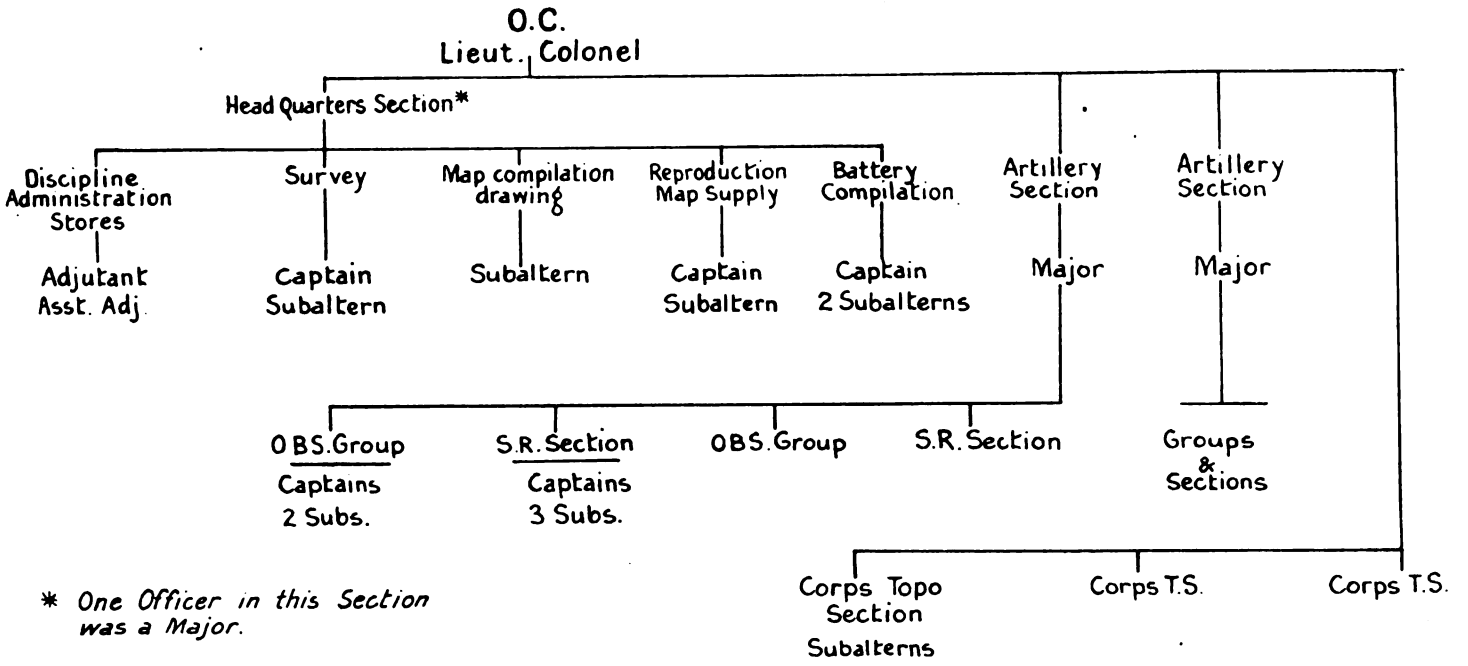
ORGANIZATION OF FIELD SURVEY BATTALION AT END OF WAR



* *One Officer in this Section was a Major.*

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Survey.—The Officer i/c Survey had a staff of 6 trig. observers and assistants, 10 topographers and about 6 draughtsmen. He was responsible for all trigonometrical and topographical work, for fixing (British) battery positions, and for making and supplying artillery boards.

Mapping.—This work consisted of the compilation and drawing of topographical detail, and the drawing of trenches from air photos. It was usually in charge of one officer, with from 30 to 40 draughtsmen.

Printing.—There were 2 printing officers, with a staff of 46 tradesmen, which included lithographers, provers and transferrers, machine minders and feeders, photographers, tradesmen for the Helio-zinc, Vandyke and Ordoverax processes, and engine drivers.

Battery Compilation.—This was the work of compiling the results obtained from the Observation Groups and Sound Ranging Sections, and occupied 2 or 3 officers and about 4 clerks and draughtsmen.

The Corps Topographical Sections included 1 officer with 5 draughtsmen and 3 topographers. They prepared small local maps for the Corps on backgrounds prepared by the F.S.B., and reproduced them on the Ellam Duplicator. The topographers' duty was to fix the positions of field batteries. These sections were Corps Troops and always moved with the Corps H.Q.

Sound Ranging Sections (4 officers and 37 other ranks) were responsible for fixing the position of enemy guns by recording their sound of discharge.

Observation Groups (3 officers and 62 other ranks) were responsible for fixing the position of enemy guns and other targets by cross observation, and for generally watching the front.

Artillery Sections.—Sound Ranging Sections and Observation Groups were allotted according to the front to be held and the nature of the operations, and it was impossible to lay down any definite number for a F.S.B. The number occasionally became unwieldy, and, during operations especially, it became difficult for one O.C. to look after the whole. In order to decentralize control and relieve the O.C. the establishment was increased by two majors, who were responsible under the O.C. for the supervision of half of the groups and sections in the battalion, under the title of an "Artillery Section."

III. Technical Development.

Artillery Survey.—With survey in the general sense I shall not deal in this article. There were many problems to be solved, but no new developments, except that trigonometrical resection assumed an importance that it had never done before in our experience. Several

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methods of resection were employed that are not in common use, and there is no doubt that this subject deserves particular attention in the future teaching of survey.

What is of particular interest, however, is the survey that was done specially for the artillery, and which we now call "Artillery Survey."

When Winterbotham was in charge of the Ranging Section, he was asked to lay out an arc for the first 15-in. howitzer that reached the country, and which happened to be located near him. This he did with marked success, and it led to numerous similar requests. It gradually became one of the duties of the observers and topographers of the Survey units to fix the positions of heavy guns and batteries. This was usually done by theodolite resection; occasionally by plane table; and later when the work was extended to field artillery the plane table was always used for their batteries. It will be remembered that the map in the early days was imperfect, and the detail often considerably out of position. The only way to ensure accuracy all round was to refer everything to the trigonometrical framework. Hence all targets and all gun and battery positions were fixed directly from trigonometrical points. As the battery usually took up its position in a concealed spot, this was as a rule carried out by resecting near the required position, and making a short traverse to it. To be successful this had to be done by expert surveyors.

This work developed greatly, but in the later stages of the war rather less attention was paid to the fixing of position than to the giving of correct direction or "line." For this purpose an elaborate system of "bearing pickets" was developed. These were pickets fixed by the F.S.B., marked with a flag or disc, and numbered. The R.A. were provided with a printed list of these pickets, giving the bearings from each to a number of surrounding conspicuous points. The battery commander could place his guns in any convenient site near a picket, and by setting up a director over the picket, could give parallel line in any required direction to his guns.

In all the later battles, when bombardments were begun without any previous registration, this matter of having line accurately fixed became of the highest importance; and the great success of these surprise bombardments may be attributed in no small degree to the work done by the surveyors. This was acknowledged on many occasions. After the battle of Cambrai (Nov., 1917) the Third Army Commander sent his personal thanks to the 3rd F.S.B. for the excellent work they had done; in Italy the G.O.C. the British Forces mentioned the work of the 6th F.S.C. in orders; and recently Sir Douglas Haig has made special mention in his final dispatch of the work of the Field Survey Batts. in this connection.

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Besides giving line, the provision of artillery boards entailed heavy work on the F.S.B. The gunner began the war by measuring his range and bearing with a six-inch protractor and a bit of string, on a map that had been folded, and which he tried in vain to spread flat on a table. He finished it with an elaborate board, made of 3-ply wood, or sometimes zinc covered, on which his map was pasted down in small sections placed accurately in position. On this board his gun positions were exactly marked, and a paper arc for each position was pasted, of large radius, and reading to 10 mins. This arrangement was termed an "Artillery Board."

These boards were manufactured partly in France (by the F.S.B. carpenters) but mainly by the Ordnance Survey. They were prepared and supplied entirely by the F.S.B. Some idea of the numbers involved may be gained by the fact that every battery required one spare board, besides others prepared for reserve positions.

Towards the end of the war an official pattern of artillery board was designed, having a metal arc and a pivoted metal scale which could be fixed to suit any battery position. As these were only supplied at the rate of one per battery, the F.S.B. were not relieved to any appreciable extent.

All this work should undoubtedly have been done by the R.A. themselves, but they had had no training for it. In any future war they will no doubt be independent in these matters. In the meantime, when the excellent work of the artillery is mentioned, it will I hope be remembered that the R.E. surveyor had no small share in contributing to their success.

MAPPING.

To understand the mapping problem and how it was solved it is necessary to have some idea of the material already existing in the country.

Belgium.—The whole of Belgium is covered by a very fair topographical map, published on the 1/40,000 and 1/20,000 scales. We had the plates of these maps and could print what we liked.

France.—In France no large scale maps had been published. The Fortress Plans Directeurs had been prepared in peace time, for the areas around fortresses and along the frontier, as a secret map. These were topographical maps on the 1/20,000 scale, of good quality, but not always up to date For the rest of the area with which we were concerned no maps were readily available except the French General Staff map on 1/80,000 scale.

A cadastral survey of France had, however, been carried out

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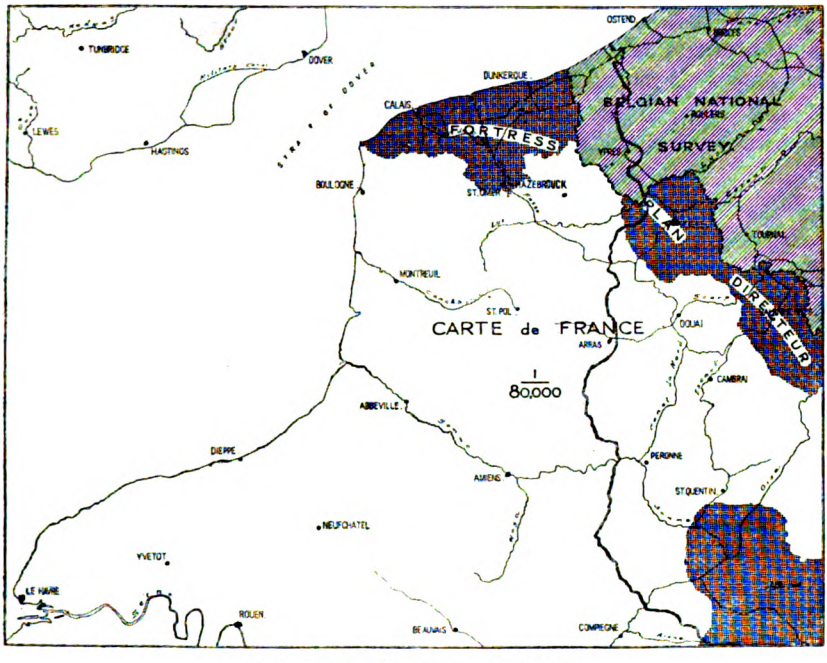
early in the nineteenth century (mostly between the years 1830 and 1850), but it was never published. The manuscript drawings of this survey exist in triplicate, and are kept at the Mairies of Communes, and in the chief towns of Departments. This survey is mostly of good quality, but each commune was done independently, and there was no trigonometrical framework. The documents consist of an enormous number of small drawings on 1/2,500 scale, with a number of MS. compilations or index diagrams on the reduced scale of 1/10,000.



Material Existing before the War.

The material available was thus, for Belgium and a strip along the frontier, a topographical map that was good but not altogether up to date; and for the rest of the area nothing but the small scale 1/80,000 and the old cadastral survey existing in manuscript only.

In 1914, when it became evident that larger scale maps were a necessity, we were puzzled to know what to do. It seemed almost folly to start detailed survey in the field. No one realized how long the war was going to last, and everyone had the idea that a "break through" was possible, and that the line might move at any moment.

An attempt was made to use photographic enlargements (to 1/20,000 scale) of the 1/80,000 map. This was almost immediately found to be useless. The errors in the original map, and the mag-

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nification of the generalized detail of a small scale map, made such an enlargement out of the question for accurate work. An effort was then made to revise the map, and correct its errors, using as a basis the photographic enlargement. This proved equally useless. It was therefore decided to start a topographical survey *ab initio*.

I have already mentioned the Ranging Section, which was working under Winterbotham. This formed a nucleus of expert surveyors, and Winterbotham had much experience of supervising survey in the field. He was put in charge of the work, and his section augmented by observers and topographers obtained from the O.S. Southampton, and recovered from various units in the field. The survey was done at great speed, for fear it should be too late to be of use. The basis was the existing French triangulation, the positions of whose points were obtained from the Service Geographique. The front then extended from Ypres to La Bassée, and the area surveyed was up to some 40 kilometres to the rear, excluding portions covered by Belgian maps or French Fortress Plans Directeurs. Work was begun on 25th January, 1915, and on 28th February the field work was complete and was sent to the Ordnance Survey for reproduction. This survey, though owing to the haste with which it was done it was not perfect, was an enormous advance on anything previously available, and for the first time our artillery had a reliable map on which to work.

Subsequent surveys were carried out at less speed and consequently with greater refinement and accuracy. With each extension of our line it became necessary to survey the country on our side and produce a reliable map.

Some of the difficulties encountered in this kind of work in the field have their interest. The first surveyor who appeared with a theodolite was arrested as a spy, on the ground that no one but a German would be likely to use such an instrument in our area. These difficulties were enhanced when our men were working in or near an area occupied by French troops, and it became a common experience for topographers to be taken into custody. Eventually we had to provide every man with an elaborate passport, bearing as many signatures and office stamps as it was possible to crowd on the the sheet; after which they were able to do their work with less interruption. It has been said with some truth that in this, as in other services, the difficulties of contending with the enemy were insignificant compared with the obstacles placed in the way by our own friends. One F.S.B. Commander stated that his three chief enemies were rumours, tanks and Australians. The first caused unauthorized movements; the second picked up and carried away all telephone cables; and the third took anything they saw. In one

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area the greatest difficulty was experienced in preserving any kind of trigonometrical signal or picket. It was found that there was only one kind of monument that was respected, and thereafter every trigonometrical point was made secure by marking it "Grave of an unl nown soldier of the —th Field Survey Battalion."

Pressure of work was so great that it was never possible to survey more than a fairly wide strip behind our line. Consequently, when the great German attack in March, 1918, drove us back to Amiens, we found ourselves without any large scale map in rear. The work of survey was immediately put in hand, and carried out with great speed; but fortunately it was not required for use against the enemy. The methods employed on this survey of back areas are extremely interesting from the survey point of view, but to describe them would occupy too much space for this article.

The above account relates to survey behind the front line, where we could get on to the ground. But we had also to produce maps of the other side, of country we could not reach, and this presented a totally different problem. At first the only material we had on which to base our work was the French triangulation points and such points as we could fix ourselves; and for detail, air photographs. But the French trigonometrical points were often unreliable, partly owing to their destruction by the war; partly to removal of signals (such as church towers) during peace, and their re-erection on adjacent, but different, sites; and partly to arithmetical and other errors in the positions given. Air photos were also often unreliable, owing to the errors and distortions to which they were subject. Consequently a map constructed from distorted air photos based on few and uncertain trigonometrical points did not meet the requirements of the case. Fortunately we learned of the existence of the old cadastral plans which I have mentioned. These provided a good topographical framework, on to which the air photos could be fitted, and formed a most valuable control. It is true that these cadastrals were 80 years old, and that in some cases detail had altered or disappeared; but it is astonishing to find how little on the whole detail does change, and how old boundaries, hedges and topographical features persist in spite of modern innovations.

The maps of the forward areas were therefore constructed on a framework of old cadastrals, controlled by such trigonometrical points as could be fixed, and with detail corrected and brought up to date by air photos, and also by such mine plans, and railway and canal plans and sections as were available.

In this way we were able to produce a map that was reliable in plan; but the problem of contouring remained an extremely difficult one. Use was made of the levels of the French Nivellement General, and of all railway and canal plans and sections that could be obtained;

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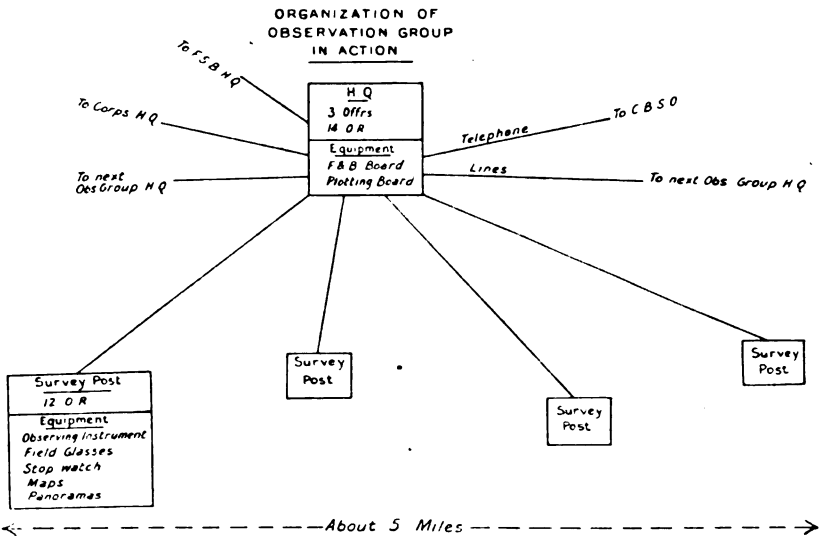

material from all arms, and were given a thoroughly sound practical training at the School for Observers. They were taught the use of the instrument, flash observation on a dummy range, map reading, something of the construction of a map, and use of the stop watch, and were generally trained to use their wits and become useful, intelligent observers.

An Observation Group is a unit organized and trained for the purpose of fixing objects by cross-observation; and especially of fixing the position of guns by observation of their flashes. The duties of Observation Groups included watching all ground to their front, and fixing and reporting the positions of any target or unusual occurrence; but by far their most important and difficult duty was that of fixing guns, or "flash-spotting."

The problem of flash spotting may be said to consist in training observers to observe flashes, and directing them on to the same flash. This is a difficult matter, when, as usually happens, a number of guns are firing in the area under observation.

Various methods were tried to secure observation of the same flash, which was ensured only when the observations were simultaneous. At first the time (to the nearest second) of every observation was booked. This meant frequent and careful synchronization of watches, and subsequent comparison of the timed observations; a laborious process, which produced some, but not many results. Other methods were tried, and valuable ideas were obtained from a French flash spotting group. Finally the "Flash and Buzzer Board" was evolved, the design being due to Major (then Lieut.) Hemming, a young Canadian holding a temporary

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commission in the R.A., and one of our most capable observation officers.

The flash and buzzer board is a small telephone exchange, by which the operator can speak to any or all of the four survey posts as required. It has four* small electric lights, and four buzzers; and it can be arranged that the observers either show a light, or sound a buzzer, by pressing a key at the Survey Post. The procedure in flash spotting is usually that one observer leads, observing the flashes of a certain gun. Each time he observes the flash he presses the key at his post, and the corresponding light appears on the F. and B. board. A second observer is directed on to what is believed to be the flash, observes, and presses his button each time he sees it. If he is on the same flash the two lights appear together. Similarly the other observers are put on, and if the observation is successful all four lights will appear together; three being, of course, the minimum necessary for certainty. As soon as the operator is satisfied that the observers are on the same flash he tells them to book their readings. These are reported to H.Q., the bearings are laid out on a specially prepared board, and the position of the flash fixed.

An obvious development of this system is to fix the position of the burst of our own shell, and hence to observe for "ranging" our own fire. This developed to such an extent in the later phases of the war that in several cases the M.G.R.A. of the Army considered it of more importance than the fixing of gun positions. Ranging by this method is evidently far more accurate than the usual method, whereby a single observer reports "short" or "over," and estimates the amount.

A further development is to fix the position of the shell when bursting in the air, and so to range on to an invisible target. This is simpler in practice than it sounds, and became part of the regular procedure.

Sound Ranging.

The problem of locating the position of the point of origin of a sound depends on the well-known fact that sound travels at a uniform velocity, subject to slight variations due to temperature and atmospheric conditions. Thus if you can determine the interval of time between the arrival of the sound wave at two fixed points you have the data necessary to enable you to fix the *direction* of the sound.

Thus in the diagram, A and B are two fixed points, and the sound wave reaches B x seconds before it reaches A. Describe a circle

* In the latest pattern there are six.

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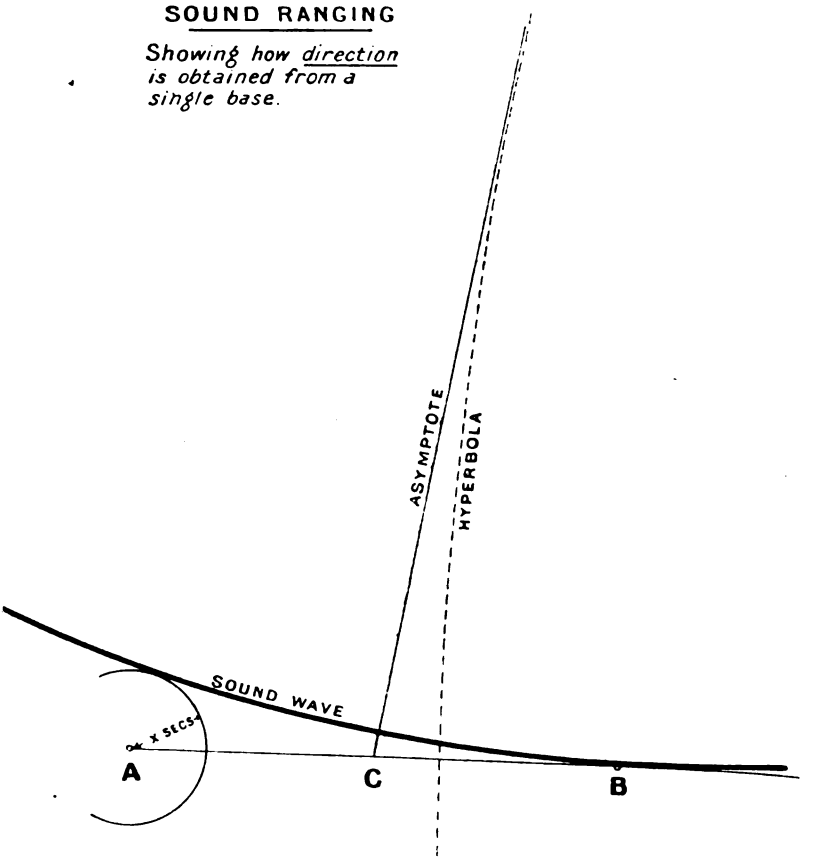
with A as centre, and radius equal to the distance travelled by sound in x seconds. Describe any circle which passes through the point B, and is tangential to the small circle described round A. Then the centre of the big circle is a possible position for the origin of sound, say a gun. An infinite number of circles may evidently be described passing through B and touching the small circle. Actually the locus of the origin of sound is a hyperbola whose foci are the points A and B, and this hyperbola gives the direction of the sound. In practice



instead of the hyperbola we use the asymptote, the error for points not in the neighbourhood of the base AB being small and easily corrected. It is easy to see that for a given base AB a time scale can be constructed, having its zero on the perpendicular passing through the mid-point of AB, and having time divisions, corresponding say to hundredths of a second, to the right and left of this zero. Then if instruments at A and B record the time of arrival of the sound at each point, one has only to set a fine string pivoted at C

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(the mid point of the base) at the scale division corresponding to the time interval, to get the direction of the sound with reference to AB. In other words a single base, with a recording instrument at either end, gives you a bearing to the sound.

The possibility of locating gun sounds in this manner had been discussed some years before the war, but no practical application of the idea had been made. The French took up the question immediately after the outbreak of war, and at first devised a system of a measured base, with three human observers, each with a stop watch, who would record the instant the sound reached them. This human observer method continued in use, with considerable success, for a long period, and was used by the Germans throughout the war. Later experiments evolved automatic apparatus of various kinds.

French sound ranging soon attracted attention in the British Army, and Colonel Blandy, R.E. (Signals), wrote a report on it. In April, 1915, Colonel Hedley, R.E. (Geographical Section, G.S. War Office), was so impressed by what he saw and heard on a visit to Paris, that he came straight back to G.H.Q. and reported on the subject to various senior officers. The result of this was the dispatch of a Committee of three to report on French sound ranging. The Committee consisted of Major Winterbotham, R.E. (survey expert), Captain Lefroy, R.E. (electrical expert), and an R.A. officer. The R.A. officer, after the first day in Paris, returned to G.H.Q., and thereafter dissociated himself from the reports of the Committee. I mention this merely as a matter of historical interest, because the matter was one which, if it was to be of any use at all, was of paramount importance to the artillery. The two Sappers continued their investigations, and made a report which was a model of its kind. Considering how little was known of sound ranging at that time, and in what a crude state the French system was, it is a great testimony to the ability and foresight of these two officers that the report and recommendations they made hold good to this day, and have been amply justified by the event. The gist of their report was that—

(1) Sound ranging though in its infancy was a practicable proposition, and would give valuable results.

(2). The Bull system was the best.

On receipt of this report the Committee was sent on a second visit to see the working of a French sound ranging section at the front. Their second report confirmed the first.

At G.H.Q. there was much apathy, and some opposition. The matter was put before the Experiments Committee at G.H.Q., and they decided against ordering any apparatus. It fell to my lot to combat this decision, and after some discussion I got it rescinded,

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and one set of apparatus was ordered, and was delivered from Paris in October, 1915.

In the meantime Colonel Hedley had secured the services of W. L. Bragg, at that time a lieutenant in the Leicestershire R.H.A. Bragg is one of the most brilliant of our younger scientists, and is also a very sound practical man, and we were fortunate in securing his services. He remained with us throughout the war as our chief sound ranging expert, and was later on my staff at G.H.Q. He, with two other officers and half a dozen men, constituted the first S.R. Section.

This section suffered under every kind of handicap. It had to try and produce practical results, while at the same time carrying out research. Mistakes of all kinds were made; in the survey, in the length of base, and in methods. It seemed indeed doubtful if it would be possible to produce those results which the authorities required as a justification for the existence of the section. However, results that just satisfied requirements were obtained, and in December it was decided to form seven more sections, making two for each of the four armies then in the field.

From that time sound ranging advanced. As soon as the eight sections were working the call came for more, and in the end the artillery recognized that sound ranging was an essential part of their equipment.

A Sound Ranging Section in action consists of the microphone base, the forward observer, and the central recording apparatus. The base consists of six microphones, each pair of which constitutes a sub-base which gives a bearing as shown in the explanation given above. Thus if all six microphones respond, five bearings are obtained to the gun. The length of the base is about 9,000 yds. and it is our practice to space the microphones equally and regularly either in a straight line or more commonly on the arc of a circle.

The microphone is a most important part of the apparatus. Much trouble was experienced with the early microphones, partly because they responded to any casual noise, and partly because of the difficulties caused by the shell wave (*onde de choc*). The shell wave is the sound made by the shell travelling through the air, and in the case of a high velocity gun it travels in advance of the true sound of the gun discharge, and produces a false record. What was wanted was a microphone that responded only to sound waves of larger amplitude, such as those produced by a gun discharge, and that was very well damped. Such a microphone would not be affected by rifle firing or casual sounds, and would also readily take up sounds at short intervals and so distinguish between guns firing rapidly, and also as a rule between the shell wave and the gun discharge. Lieut. (now Capt.) Tucker, R.E., devised a microphone which satis-

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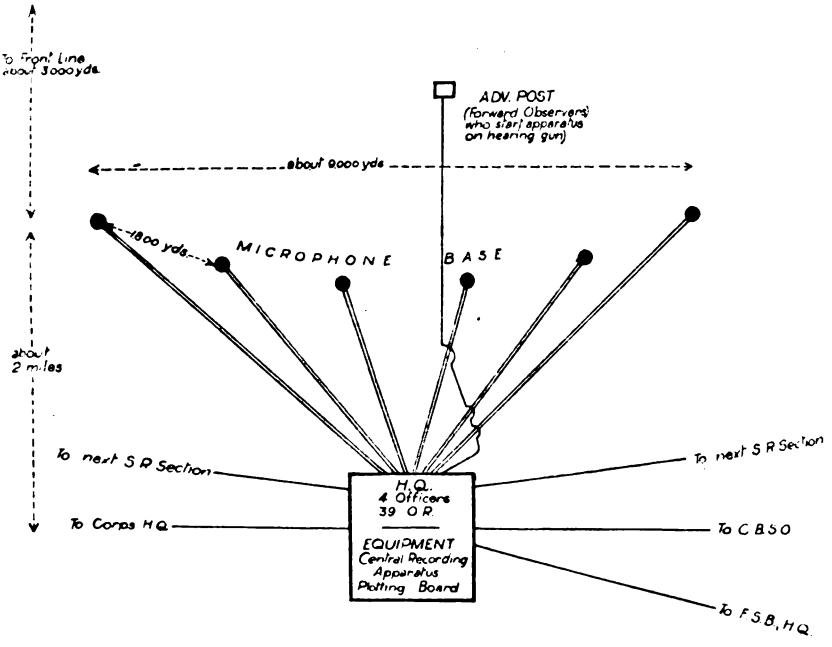
fied these conditions almost perfectly, and the invention of this microphone constituted the biggest stride made in sound ranging since the introduction of the graphic recording apparatus.

ORGANISATION · OF
SOUND · RANGING · SECTION
IN · ACTION



The forward observer is situated sufficiently far in advance of the microphone base to give him time to press a button and set the recording apparatus in motion after hearing a gun which he wishes to record. This usually means about 1,000 yds. in front. The forward observer's task is by no means mechanical. He requires an expert knowledge of gun sounds, including nature, direction and probable position, as well as an intimate acquaintance with his portion of the front. A good forward observer is essential to the successful practical working of the section. There are ten forward observers in a section, to allow for reliefs, and it is common practice to have two forward observing posts.

The recording apparatus used by us is that designed by Mr. L. Bull, a British subject resident in Paris. The principle is that of the Einthoven galvanometer, which consists of an electro-magnet between whose poles pass fine wires. An electric current passing through any of these wires produces in it a deflection. In the Bull

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apparatus there are six wires, each connected with one of the microphones in the field The shadows of these wires are projected by a suitable lantern on to a cinematographic film, on which at the same time cro divisions are marked, representing short intervals of time. So long as the wires are unaffected they appear on the film as straight lines, but when a microphone responds to a sound a current passes through the corresponding wire, and it twitches and the line on the film is broken. The record thus forms a ready means whereby the required time intervals can be measured with great accuracy. (*See Plate*).

As in the case of flash spotting, an obvious extension of the system of sound ranging is to determine the position of our own shell bursts and so to range our own guns. This can be done with the greatest effect when ranging on to a battery that has just fired. The two determinations of position (of hostile battery and our shell burst) being made within a short interval are subject to the same errors caused by wind, temperature, etc., and these errors cancel out. The difference between the two records represents the error of the position of the shell-burst with reference to that of the battery, and all that is required is to bring the record of the shell-burst to agree with that of the battery, to ensure that the shell is falling on or close to the target. The method is in fact a differential one, and it is not necessary to know where the hostile battery is—it may be one that has never fired before. An ingenious mechanical plotter was devised by Bragg whereby the necessary corrections could be supplied to our gunners in a very short time, in terms of yards short or over, minutes right or left.

Battery Compilation Section.

This was the logical outcome of the work of the observation groups and sound ranging sections. Some one had to co-ordinate the work and collate the results obtained, and this was naturally done in the F.S.B. who were responsible for obtaining the results. A further reason was that, in the early days especially, a decision as to true position was intimately bound up with a knowledge of the local value of the map. The work was, however, so closely connected with Artillery Intelligence that, as the latter became an organized service, the desire on the part of the R.A. to incorporate the compilation section in the office of the M.G.R.A. grew; and towards the end of the war the compilation section was in all cases located in or close to the R.A. Office.

Compilation of battery fixings demands considerable experience, sound judgment, and an intimate knowledge of air photos. The various fixings usually indicate a small area in which the battery lies:

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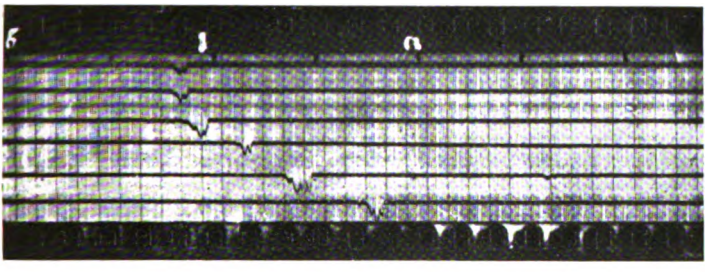
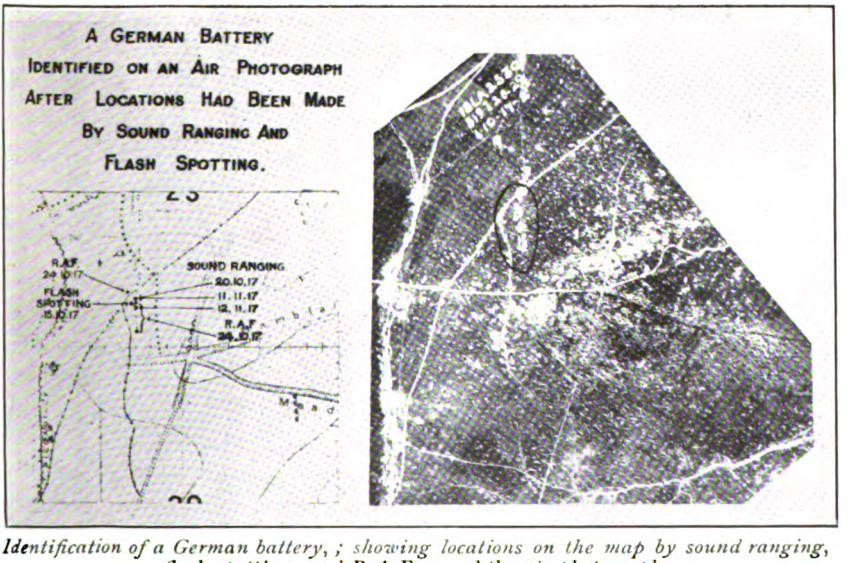
SURVEY IN FRANCE DURING THE WAR.



Specimen of a sound ranging record.



Identification of a German battery, ; showing locations on the map by sound ranging, flash spotting, and R.A.F. ; and the air photograph.

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and the air photo is practically always taken as the final evidence of position. It may be mentioned, however, that there have been occasions when the air photo appeared to disagree with the results of the group and section fixings, and the latter were discarded; and that it was found later that the fixings were right, but that the photo had failed to reveal the presence of the battery.

The division of responsibility agreed upon was that the F.S.B. decided position, and the R.A. activity. (*See Plate*).

These two systems of gun fixing—by visual observation and by sound ranging—are complementary, and neither is complete without the other. It is necessary to enter a caution about this, because sound ranging has attracted so much attention that it is often spoken of as if it were the one and only method of fixing guns, or at any rate the most important. It is, however, impossible to say that one is more important than the other. Each can do what the other cannot. Flash spotting is unaffected by wind; but, for fixing enemy guns, it is less effective by day than by night. Sound ranging is unaffected by rain or fog, and is equally effective by day or night, but an adverse wind will put it quite out of action. Sound ranging is more economical than flash spotting, as it occupies fewer men and, given favourable conditions, gets far more locations; on the other hand the flash spotting locations are more precise.

Another point that may be mentioned is the question of the mobility of these units. It is incorrect to say that their methods are suitable only for absolutely stationary warfare. Both are of great value in semi-mobile warfare, the degree to which they can be used depending naturally on the rapidity of movement. The proper way to gauge their value in this respect is to consider their mobility in comparison with their objectives, and it may be said without hesitation that, given the necessary transport and personnel, a S.R. Section can move from an old position and get into a new one at least as quickly as heavy artillery, while an Observation Group can do so a great deal more quickly.

We were naturally very anxious to check, by actual examination on the ground, the results of battery fixing by these methods. Various opportunities occurred; after the German retreat on the Somme, after the battles of Arras, Vimy Ridge, Messines, etc. The results were in every case highly satisfactory. Of German batteries actually identified on the ground it was found that about 90 per cent. had been accurately located. Of reports of battery positions sent to the R.A. it was proved that the proportion of inaccurate or non-existent positions was very low, something under 5 per cent. In other words the F.S.B. succeeded in locating nearly all the German batteries, and the information given by them to the

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Artillery was accurate and reliable. One could hardly ask for better testimony.

I have tried in this somewhat brief account to give some idea of the work of the survey organization in France. There are many aspects of that work which I have not touched; such as the trigonometrical and levelling problems, magnetic survey, screen calibration in the field with the aid of the sound ranging apparatus, air photography in relation to survey, the preparation of maps bearing special information, and so forth. Anyone who is interested in these and kindred developments of our work will be able to read about them in the detailed official account which is now in preparation.

I have also barely referred to the work done by the S.M.E. in providing the original Printing Co. and various personnel and stores during the war, nor to the tremendous amount of help received from the Geographical Section at the War Office and from the Ordnance Survey, Southampton; but this is not because I am not conscious of the great debt we owe to these institutions.

A point that has puzzled many people, especially R.E. officers, and about which I have often been questioned, is why we mixed ourselves up so much with Artillery work. The answer is that if we had not done it, it would in many cases not have been done at all, and the Army and the nation would have suffered in consequence. Certain obvious needs came to our notice, which our training enabled us to tackle, and for which the gunners had not been trained. I can say with truth, and in no offensive spirit, that the surveyors were able to teach the gunners a good deal about their job; so much so that it is now recognized that survey is a necessary part of the gunner's training, and the future gunner will be taught to look after himself in these matters.

One last word on survey from the R.E. point of view. Before this war survey was looked upon as a legitimate and valuable occupation for the Engineer officer in time of peace, but it was considered that active survey work would cease on the outbreak of war. The surveyor's work was thought to lie mainly in map making before the war, and after its commencement he was expected to turn his attention to more important matters. The proof of this is in the arrangements made for the disposal of the Ordnance Survey personnel on mobilization. All were allotted to Field and Army Troops Cos., with the result that when we wanted them it was extremely difficult to get hold of many of these valuable men.

The war has, however, shown that Survey has a very decided military value in the field. When we take into account the smallness of our numbers (our total strength being just under 4,000) and when

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we consider all that Survey did in the war; whether we think of the accurate direction of our own guns, or the fixing of enemy batteries, or the provision of reliable maps of all kinds; I think we are justified in questioning whether there is any branch of the Army which in proportion to the numbers engaged had a greater effect on operations.

The net result is that we have started a new branch of Artillery work, which I am certain is destined to have great developments; and, as far as the R.E. are concerned, I think that it will be recognized in future establishments that no formation should ever take the field without its proper equipment of survey personnel.

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HISTORY OF THE RAILWAYS AND ROADS TRAINING CENTRE, R.E., LONGMOOR.

By COLONEL H. M. SINCLAIR, C.B., C.M.G., C.B.E. (LATE R.E.).

BEFORE the War Longmoor was the Headquarters of the Railway Companies, R.E., which consisted of the 8th and 10th Regular Companies. Three Special Reserve Companies (two Monmouth and one Anglesey) also came to Longmoor annually for training, which was carried out technically on the Woolmer Instructional Military Railway.

On the outbreak of War in August, 1914, the above five Companies were mobilized, and the 8th Company proceeded at once to France. In October, 1914, Lieut.-Colonel J. H. Twiss, R.E., Commanding Royal Engineer, Longmoor, left for France as Director of Railways, and Colonel H. M. Sinclair, C.B., was appointed in his place as O.C., Railway Troops.

It was decided to raise four Constructional Companies, each with a strength of six officers and 250 other ranks, as early as possible, for service in France. Officers and men for these Companies began to arrive in October. Both officers and men had to be trained simultaneously, with the aid of officers of regular companies still at Longmoor, and old R.E. warrant and non-commissioned officers called up for the purpose. At first it was intended to send these companies out in a fortnight; but the exigencies of inoculation, vaccination, drill and musketry soon showed that this could not be done. Nor were the demands from France sufficiently pressing.

RAILWAY CONSTRUCTION TROOPS DEPÔT, R.E.

In December, 1914, it became apparent that the existing nucleus of a Depôt must be enlarged for the receipt and training of recruits, the preservation of documents, and generally dealing with the rapidly increasing *personnel* of the Railway Troops. This was organized first under Capt. J. M. Burn, R.E., afterwards Capt. G. J. Watt Smyth, R.E., and other officers in succession. Lieut.-Colonel May, R.E., has been in Command since 21st May, 1917. As the numbers of men at Longmoor steadily increased it became necessary to obtain a recognized establishment for this Depôt, which had to be modified from time to time till it has assumed the *personnel* now given in "War Establishment" 1196, Part V., of 3rd May, 1918. The following is a summary of the organization and history of the Railway Construction Troops Depôt, R.E.:—

Formed December, 1914.—Establishment 300 all ranks.—Revised 624 all ranks on 19th June, 1915, including Headquarters, Railway

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Troops, R.E.—Revised 814 all ranks on 1st August, 1916.—Revised 1139 all ranks on 3rd May, 1918, exclusive of Headquarters, Railways and Roads Training Centre, R.E.

Title.—Changed from Railway Troops Depôt, R.E., to Railway Construction Troops Depôt, R.E., on 14th December, 1917.

Number of men sent overseas :—

1914	...	...	750	1917	...	...	6,212
1915	...	...	2,250	1918	...	...	3,188
1916	...	...	4,252	1919	...	...	71

Average strength :—

1914	...	...	200	1917	...	...	1,800
1915	...	...	750	1918	...	...	2,082
1916	...	...	1,200	1919	...	...	1,655

Disposition.—Depôt run as one company until April, 1916, and becoming too unwieldy under these conditions (1,000 strong) was split into four companies :—

Headquarters...		(Administrative).
A and B	...	(Recruits and Draft producing).
C	... ...	(Miscellaneous ; also Draft producing).

In October, 1916, the functions of the companies were organized as follows :—

Headquarters...		(Administrative).
A	... ...	(Recruits and Training).
B	... ...	(Miscellaneous).
C	... ...	(Draft Producing).

The Railway Construction Troops Depôt, R.E., finds all reinforcements for Construction Companies, 30th Railway Labour Battalion, 270th and 271st Railway Labour Companies, Railway Store Park, Railway Transport Establishment, such as Mediterranean Lines of Communication, etc.

During 1914—1915, owing to lack of experienced staff, and speed with which drafts had to be despatched to Expeditionary Forces, the organization of the Depôt was unavoidably far from perfect.

The average time required for a recruit to complete his training including musketry and gas, and to be granted overseas leave, was ultimately from 7 to 8 weeks.

During March, 1916, when a great blizzard swept the country, from three to four hundred men were loaned to various Railway Companies for several months to repair damage done to telegraphic wires, etc. A letter of appreciation and thanks for the assistance given by the Railway Troops in this connection was afterwards received from the General Manager of the Great Western Railway, through the War Office.

Meanwhile the demand for new Construction Companies and reinforcements for those already abroad continued to increase. When

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a sufficient number of recruits had been assembled in the Railway Construction Troops Depôt, R.E., one new company could be formed full fledged from the Depôt ; but others were obtained complete, with a proportion of officers, direct from the British Railway Companies.

It will suffice to give Appendix A which is a list of the Construction Companies formed at Longmoor from 1914 to March, 1919.

Two Railway Labour Companies of men over military age, and voluntarily enlisted, were formed at Longmoor during 1915 (Nos. 270 and 271). Early in 1916 authority was given for the enlistment of a Labour Battalion on similar lines by Major Peake, in and about Gloucestershire, consisting of four companies of 250 each. This Unit formed and trained at Longmoor, and left by companies as shown in Appendix A.

It may be mentioned that at first C.S.Ms. and C.Q.M.Ss. for all Construction Companies, Inland Water Transport, and Railway Operating Division Sections, were found from such old Army N.C.Os. as were available. Later all C.S.Ms., C.Q.M.Ss., Pay Corporals, etc., were provided from men specially trained at Longmoor, or when transfers from other arms were authorized, from the best men of any origin.

Inland Water Transport, R.E.

In January, 1915, the Inland Water Transport branch of the Royal Engineers was started, and officers and men engaged for it began to arrive at Longmoor under the command of Major Luck, R.E. This formed a separate unit under the O.C., Railway Troops, and was quartered at the Applepie Huts, then approaching completion. It was organized in sections of two officers and 250 other ranks each, and the training carried out under its own officers, assisted by such warrant and non-commissioned officers of the old R.E. as were available.

This Unit remained at Longmoor until May, 1916, and during the time it was here 138 officers and 4,064 other ranks were sent overseas. As the numbers were becoming too great for the accommodation at Longmoor, the unit was removed to Richborough, where large works were in contemplation.

It will thus be seen that the early training of the Inland Water Transport, R.E., including many officers, non-commissioned officers and men who have since risen by rapid promotion to high rank was received at Longmoor.

Canadian Overseas Railway Construction Corps.

In June, 1915, the Canadian Overseas Railway Construction Corps, numbering 20 officers and 500 other ranks, reached Longmoor from Canada with some 650 tons of Canadian construction material, tools, and machinery, under the command of Lieut.-Colonel Ramsey of the Canadian Pacific Railway.

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This Unit completed its training under the O.C., Railway Troops as a separate unit, went to France on 28th August, 1915, but returned again to Longmoor on 6th October, 1915, and finally left on 1st November, 1915.

It was reviewed by His Majesty the King, on the 18th July, 1915, with the other Railway Troops.

Railway Operating Troops Depôt, R.E.

In April, 1915, another unit, the Railway Operating Division, R.E., began to form at Longmoor. Hitherto Construction Companies and small bodies of Railway Transport Establishment, Railway Store Park and Military Forwarding Establishments, had been formed. It had now become necessary to provide for the working and operation of railways overseas as well as construction and maintenance.

This unit was organized in sections of 266 men with no specific number of officers, the various operation trades being in fixed proportion. As this unit was at first to be unarmed, the training was simple drill, and the men could be passed through rapidly. It resulted that as the authorized trades could not always be provided in proper proportions, the sections went out incomplete in trade-numbers, and the requirements of each section were never fully met, until the time when, owing to the reorganization of the Railway Troops, R.E., in the autumn of 1916, the system was changed, and the companies of various composition were organized at Longmoor and sent out, as far as possible, complete.

Consequent on the reorganization and expansion of the Railway Troops undertaken in the autumn of 1916 by Major-General Sir E. Geddes, the Railway Operating Division was reorganized, and it was decided in January, 1917, to send out complete companies under the following titles, as well as keeping up the supply of reinforcements:

	No. sent out.
Broad Gauge Operating	3
Light Railway Operating	11¼
Broad Gauge Train Crew	0
Light Railway Train Crew	6
Broad Gauge Workshops	3
Light Railway Workshops	3
Broad Gauge Misc. Trades	4
Light Railway Do.	2
Broad Gauge Wagon Erecting	3
Electrical Sections	3
Engine Crew Companies	4
Transportation Stores Co.	¼
	42½

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It was decided that these companies should be armed in the same proportion—10 per cent.—as the Railway Construction Troops, so musketry had to be added to their training, as well as instruction in anti-gas measures.

The total number of officers and men sent out from the Railway Operating Troops Depôt, R.E., between April, 1915, and 11th March, 1919, is as follows:—

Officers	494
Other Ranks	26,089

Appendix B gives the list of Railway Operating Division Companies and the dates on which they were sent out.

The Railway Operating Troops Depôt, R.E., was first given a definite establishment in January, 1917, and has been commanded by the undermentioned officers since its formation:—Lieut. Ince, R.E., from April, 1915, to October, 1915. Lieut. (later Captain and A/Major) L. B. Shoppee, R.E., from October, 1915, to August, 1917. Major (now Lieut.-Colonel) P. D. Michod, O.B.E., R.E., from August, 1917, to date.

Title.—Changed from Railway Operating Division, R.E., to Railway Operating Troops Depôt, R.E., on 14th December, 1917.

In June, 1915, the Quarter-Master-General inspected the Railway Troops and C.O.R.C.C. It was arranged that this should take the form of a review and march past in Blackmoor Park. About 400 men of the R.O.D., took part, more than half of whom had only been enlisted about a week. Each unit marched past in column, with a creditable alignment. But the 2nd Company of R.O.D., 200 strong, consisting entirely of men who had only drilled for a week, passed the saluting point in an absolutely wall-like line, as good as any company of Guards. On Col. Sinclair's informing General Cowans of their length of service, he remarked, "Well, Sinclair, I cannot understand how you do it!" No doubt it was a happy accident, but it shows what can be done by men of intelligence under experienced guidance.

Military Camp Railways.

Railways to various camps had been laid during their construction for the convenience of contractors. Most of these camps were approaching completion early in 1916, when it was determined to keep the railways working for the supply, etc., of the camps.

Already the O.C., Railway Troops, had been called upon to make surveys and estimates for certain proposed military railways on Salisbury Plain, at Witley Camp, etc. It was decided to entrust the maintenance and working of the railways to the O.C., Railway Troops, R.E., with a military organization for the purpose.

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The following table shows the lines taken over, and the dates on which they came on charge :—

Command.	Designation.	Main Line Connection.	Mileage.	Date taken over.
Southern ...	Larkhill ...	Amesbury, L. & S.W. ...	9 miles	25. 5. 16
do. ...	Fovant ...	Dinton, L. & S.W. ...	3½ miles	20. 5. 16
do. ...	Codford ...	Codford, G.W.R. ...	4¼ miles	3. 6. 16
do. ...	Sutton Veny ...	Heytesbury, G.W.R. ...	5 miles	3. 6. 16
Northern ...	Catterick ...	Catterick Bdge., N.E.R.	21 miles	29. 7. 16
do. ...	Ripon	Ripon, N.E.R.	7¾ miles	30. 5. 16
do. ...	Cannock Chase	Milford and Brocton, L. & N.W.R.	13¼ miles	11. 6. 16
do. ...	Clipstone ...	Mansfield, G.C.R. ...	4 miles	25. 7. 16
do. ...	Grantham ...	Grantham, G.N.R. ...	6¾ miles	1. 6. 16
Western ...	Kinmel Park ...	Foryd, L. & N.W.R. ...	6¾ miles	7. 8. 16
do. ...	Prees Heath ...	Whitchurch, L. & N.W.R.	1 mile	25. 5. 16
do. ...	Oswestry ...	Oswestry	3½ miles	8. 8. 16

To these must be added the Woolmer Instructional Military Railway, which has always been worked from Longmoor, the Bisley, Deepcut and Blackdown Railway, constructed and maintained from Longmoor in 1916—1917, the Altrincham Depôt Railway, and the line from Westenhanger to Lympne Aerodrome. In addition lines were constructed from Farnborough to the Aldershot Aircraft Factory, to the Ascot Flying Corps Stores, and for sidings at Abbey Mills, mainly by labour, and under the direction of Longmoor. The number of officers and men permanently employed on these Military Camp Railways was at first five officers and 448 other ranks, and rose to six officers and 673 other ranks. Lieut.-Colonel R. G. Aston, O.B.E., R.E., was placed in charge of these railways.

Besides the permanent Establishment large numbers of men on loan from Longmoor have from time to time been employed on the construction, improvement, balasting and maintenance of these railways. Those taken over were merely contractors' lines which required a serious amount of labour and expenditure to bring them up to a reasonable and safe standard, including repair and renewal of bridges, realignment of track, deviations, balasting, lifting and provision of extra sidings, platforms and signalling systems.

The Military Camp Railways were taken over by the Director of Movements, War Office, in April, 1918, and have since been administered from his office with *personnel* provided from Longmoor.

Road Troops.

The Road Troops began to form at Longmoor in December, 1916, under the Command of Major Michod, R.E. In February, 1917, they were removed to Aldershot owing to lack of accommodation and remained there until November, 1917, when they were brought back to Bordon to fill up accommodation available there. They were again moved to Aldershot in October, 1918, thence to Woking and returned to Longmoor in February, 1919.

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The Road Construction Companies had an average Establishment of 4 officers and 256 other ranks, and a depôt was authorized consisting of headquarters, and two companies, later increased to four. The number of companies formed and despatched overseas is shown in Appendix C. On Major Michod being transferred to command of the R.O.T.D., R.E., Major Haughton, D.S O., Ox. and Bucks Yeomanry, took command of this depôt on 1st January, 1918. The total number of men received is 12,650, of whom about 15 per cent. were rejected as unfit. 232 officers have gone overseas.

As these troops at first required but little training, and no musketry, but had merely to be clothed, equipped, inoculated, and vaccinated, and given elementary drill, they could be rapidly prepared for overseas to meet the emergent demand for their services. It will be observed that the first company went out within a month of the formation of the unit, and within six months twenty-four companies were despatched. It is understood that they arrived well within the time by which they were promised and have on the whole done good service.

At first the Road Troops were not trained in anti-gas measures. As they came to be employed in the fighting zone this was found to be necessary. In March, 1917, gas training was adopted and in September, 1918, musketry also. So the training of these men became equivalent to that of the Railway Troops and was assimilated by them with surprising rapidity, considering their advanced age and physical disabilities.

Twelve Quarry Companies were also raised at Buxton and elsewhere and were affiliated with the R. and R.T.C. for depôt purposes and reinforcements.

Accommodation.

Although the numbers of all units at Longmoor had been steadily growing during 1915—16, until in September, 1916, they amounted to 51 officers and 3,781 other ranks, yet when the reorganization of the Transportation Branch, consequent on Sir Eric Geddes' mission to France in the autumn of 1916, took place, the number began immediately to rise as new formations were demanded and the raising of Road Troops was also entrusted to Longmoor. Twenty-four Road Companies, to be formed of men over military age or of low category, or specially skilled in Road Construction were authorized to be formed, trained, and sent out as quickly as possible.

The institution of Light Railways caused a large extra demand in the Railway Operating Division, R.E., and a further demand for Construction Companies was made.

This brought on a crisis in accommodation, as the total barrack room at Longmoor was only about 3,000. Hitherto the XIV. Reserve Cavalry Regiment had been quartered at Longmoor with

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the Railway Troops. It was now removed. 4,000 quarters at Bordon and later, 2,000 at Aldershot, were handed over to the O.C., Railway Troops, and several companies were billeted in the neighbourhood in the interim. The largest number of all ranks under the command of the Commandant, R. and R.T.C., R.E., at any one time was 9,445.

Australians, Canadians and South Africans.

During 1917, the following companies of Australian, Canadian and South African, Railway Operating Division Troops, arrived for training under the Commandant, R. and R.T.C., R.E., and were quartered as shown :—

Unit.	Date of arrival.	Place.	Date of departure.	Strength. Officers.	O.R.
South African.					
No. 7 L.R.O. Co. ...	4. 3. 17	Bordon	18. 3 17	2	230
No. 8 do. ...	4. 3. 17	do.	18. 3. 17	2	235
No. 84 B.G. Misc. Trades Co. ...	28. 8. 17	do.	13. 10. 17	2	252
Canadian					
No. 13 L.R.O. Co. ...	7. 5. 17	Aldershot	9. 6. 17	3	228
			9. 7. 17	–	39
No. 58 B.G.O. Co. ...	14. 3. 17	do.	17. 4. 17	4	255
Australian.					
No. 15 L.R.O. Co. ...	27. 4. 17	Bordon	29 5[1] 17	3	223
			23. 7. 17	–	39
No. 35 B.G.O. Co. ...	19. 7. 17	do.	4. 10. 17	3	228
No. 59 B.G.O. Co. ...	27. 3. 17	do.	11. 5. 17	3	254
No. 60 B.G.O. Co. ...	11. 4. 17	do.	14. 5. 17	3	256

The Canadian Railway Operating Division have their Depôt for reinforcements and casualties at Purfleet. The Australians and South Africans at Longmoor.

Number of Companies Sent Out.

The following table shows the number of companies sent out complete from the R. and R.T.C., R.E.

Construction Companies	28
Labour Companies	6
Operating Companies	42½
Roads Companies	29
C.O.R.C.C.	4
Canadian Operating	2
South African	3
Australian Companies	4
Total ...	118½

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AMERICANS.

On 20th July, 1917, the first American Railway Regiment arrived in England, and was sent to Bordon in Camp at Oxney Farm, at first with the intention of completing training under the Commandant, Railways and Roads Training Centre, R.E. But this arrangement was soon altered and nine regiments in succession at an average strength of 1,000 passed through Oxney Camp making but a short stay. The arrangements for their camping, supplies, transport, etc., were all made by the Railway Troops, as were those for several other American units of other branches of the service which arrived at Oxney Camp subsequently.

His Majesty the King inspected one American Railway Regiment, and also the Railway Operating Division, R.E., at Bordon on 28th July, 1917.

CENTRAL REGISTRY.

As the numbers and formations increased it became difficu't to identify any particular man as to whom reference was required. A Central Registry was, therefore, instituted in April, 1917, where Index Cards of every man belonging to the Railways and Roads Training Centre, R.E., are kept and where their name, number and other particulars are recorded thus enabling the Commandant to obtain in a few minutes such trace of any man as will ensure ready reference. The Central Registry also receives all men arriving at Longmoor from any source and directs them to the unit they are allotted to.

ROPEWAYS, ETC.

During the summer of 1917, two forms of experimental Ropeways were sent to Longmoor for erection and trial.—The "Hamilton" Hand Ropeway, and a mobile ropeway with travelling ropes and winding gear and engine (The "Leeming" Ropeway), designed in the Ministry of Munitions.

Experiments and modifications were tried continuously until 25th November, 1917. The erection and working of these were inspected by a Committee of Generals and other officers from the Departments of Director-General of Movements and Railways, Ministry of Munitions, and Director-General of Transportation, France.

A Railway Track Destroyer was designed and tested at Longmoor, improved from a model used by the Germans: and is understood to have been found effective in France.

The "Rugeroni" Sleeper for use on light railway lines in marshy ground was suitably tested and found effective.

The "Kent" Monorail was also erected and tested at Longmoor.

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Schools.

Newly joined officers were, for the first year, trained under the direct supervision of the Adjutant, R.E. In October, 1915, it was found necessary to place them under the charge of an officer specially employed *ad hoc*. Since then all new officers have passed through the School. Originally the course was two months, reduced under pressure of the demand for officers to a fortnight, and since fixed at one month. About 800 officers have passed through this School since it was formally constituted. It was not till the autumn of 1918, that Officers of Railways and Roads were sent in the first instance to Officers' Cadet Battalions.

R.T.O. School.—In October, 1916, the influx of officers appointed as Railway Traffic Officers with no knowledge of railway matters made it necessary to start a School for their instruction. This has since been maintained under officers with practical experience; and 247 officers have passed through it.

A Manual for Railway Traffic Officers was compiled and edited at Longmoor, and approved by G.H.Q. in France.

Internal Combustion Engines.

The inauguration of Light Railways caused a great demand for Internal Combustion Engine Drivers, as this form of traction had never been used before on British Railways. A track of some 3½ miles of 60-cm. rails was laid at Longmoor with special curves and grades, on which steam locomotives, petrol electric, petrol, and converted Ford tractors are used for the instruction of drivers, who have largely been taken from tradesmen with no previous knowledge of I.C.E. driving of any sort. 1,720 men have been so trained up to date, with, it is understood, satisfactory results in France.

Previously in 1915, one mile of 2 ft. 6in. track was sent to Longmoor for the trials of three experimental I.C.E. tractors, which were duly carried out. One Broad Gauge Petrol-driven locomotive was also sent about the same time for trial and experiment.

Transfer Depôt.

At the end of December, 1916, transfers from other units of the army began to arrive at Longmoor in large numbers owing to the fact that many men from British Railways and of skilled trades, now urgently required at their trades, had enlisted in fighting units before or early in the War—an unfortunate result of the haphazard methods of our organization and recruiting under voluntary service. Their skill had now become more essential to the scientific services than they could be to their previous unit.

It became immediately apparent that a special organization was required to deal with the intricate work of sorting out these men, and getting their documents, etc., in order. The amount of corres-

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pondence became immense as a large proportion of men came without essential documents to show trade, medical category, conduct, clothing, and other necessary particulars.

The Transfer Depôt was, therefore, established under the command of Lieut. Romer (shortly promoted to Captain and Acting Major), and lately under Major G. N. Baines, R.E. A staff was formed out of the transferred warrant and non-commissioned officers, etc. By this means the difficulty was overcome, not without strenuous work and enormous correspondence, which if orders had been obeyed by the transferring units, would never have been wanted.

Upwards of 12,000 men have thus been dealt with, of whom over 10,000 have been sent on draft, 8,000 dentally examined, 11,100 sent on leave, 5,600 dentally treated, while some 900 have been returned as unfit, etc.

It will readily be realized that such a heterogeneous mass of men aggregated in a new unit under strange officers and conditions gave some trouble as regards discipline, and much as regards rations, clothing, preservation of barrack stores and administration generally.

It must be acknowledged that the high standard of conduct and discipline previously obtaining in the Railways Troops when recruits only were received has been lowered, and the greater part of such crime as has since occurred is to be traced to the transfers. On the whole, however, it is hoped that that standard is still a high one, due largely to the tact and powers of command of the Officers Commanding the different units of the Railways and Roads Training Centre.

RECREATION.

Longmoor being on a remote common far from town or village, it was essential to provide all possible distractions for the men. Sports, cross-country running, football, cricket, and boxing were encouraged and well supported. The Seymour Hall, in Longmoor Camp, opened in January, 1915, provided a valuable site for lectures, concerts, and for a cinema which has been purchased from Regimental Funds and run continuously for 3½ years. A weekly concert with high-class artistes has been kept up since 1914, whist drives held once a week and dances once a month. In the spring of 1916 it was found possible to organize a string band owing to the presence of several highly skilled musicians. In spite of many changes and difficulties this band has been kept going to the end, and has contributed more than can easily be expressed to the amenity of the Camp and enjoyment of all within its reach. A brass band was also kept going until demobilization set in, in the R.O.T.D.

MISCELLANEOUS.

The Railway Troops were early in the field in the matter of cultivation. Some 46 acres of heather-clad moor have been converted

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into arable land, cleaned, manured and ploughed and have yielded several good crops of potatoes and vegetables at a profit to the Government and the Troops of £1,171.

The messing of the different units has invariably met with praise from the I.Q.M.G.S.

A model laundry has been established at Longmoor which has saved the troops much money and trouble in washing and mending, and yielded a total profit of £730.

It may be mentioned that officers and other ranks of the Railways and Roads Troops, R.E., have been sent in units or detachments not only to France but to Italy, Egypt, Salonica, Mesopotamia, North and South Russia, Vladivostock, East and West Africa, besides many detachments at home for various experiments, manufacture of material, armoured trains and railway construction work, while the Road and Quarry Troops Depôt has done much useful work in the Aldershot Command.

In February, 1917, Colonel Sinclair's title was changed from O.C., Railway Troops, R.E., to Commandant, Railways and Roads Training Centre, R.E.

One serious difficulty with which the Commandant has had to deal throughout is the constant change of officers and staff due to the demands for overseas for the most skilled and experienced of all ranks, and later, to the removal from home service of all "A" men and "B1" clerks. His Adjutant has been changed six times. There have been five officers commanding the Railway Construction Troops Depôt, three of the Railway Operating Troops Depôt, and many more numerous changes in the command of companies and adjutants of the different units.

Including all units at any time under the command of the Commandant, Railways and Roads Training Centre, R.E., up to 11th March, 1919, 1,681 officers, 59,627 other ranks have been sent overseas from this Training Centre, and 28 officers, 2,633 other ranks have been demobilized. 102 officers and 3,565 men are still in the Command, making a grand total of 1,811 officers and 65,825 other ranks. All calculations are made up to and including 11th March, 1919.

The Railways and Roads Training Centre has from 1915, been directed by the office—first—of the Director of Movements under the Q.M.G., and subsequently by that of the Director of Railways and Roads under the Director-General of Movements and Railways.

The War Office was therefore responsible for the provision of officers and the enlistment and transfer of other ranks, for the maintenance of the due proportion of reinforcements and provision of new units, and generally for the direction of all technical matters.

This Training Centre has been always under Aldershot Command for discipline and administration.

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APPENDIX A.

LIST OF RAILWAY CONSTRUCTION AND RAILWAY LABOUR COMPANIES MOBILIZED AT LONGMOOR BETWEEN AUGUST, 1914, AND MARCH, 1919, FOR SERVICE WITH EXPEDITIONARY FORCES.

Designation.	Date sent overseas.	Expeditionary Force.
Old Army.		
8th Railway Co., R.E.	4. 8. 14	B.E.F. France.
10th do.	26. 11. 14	do.
R.M., R.E. (S.R.)	10. 11. 14	do.
R.A., R.E. (S.R.)	10. 11. 14	do.
New Army.		
109th Railway Co., R.E.	24. 12. 14	B.E.F. France.
110th do. ...	4. 2. 15	do.
111th do. ...	15. 2. 15	do.
112th do. ...	15. 2. 15	do.
113th do. ...	14. 4. 15	do.
114th do. ...	1. 5. 15	do.
115th do. (L. & N.W.R.)...	3. 9. 15	do.
116th do. (G.W.R.) ...	14. 12. 15	E.E.F. Egypt.
117th do. ...	23. 8. 15 & 5. 9. 15	do.
118th do. (G.E.R., N.E.R.)	15. 12. 15 & 7. 2. 16	B.E.F. France.
119th do. ...	30. 5. 16	do.
259th do. ...	30. 1. 17	do.
260th do. ...	3. 2. 17	do.
261st do. ...	26. 2. 17	do.
262nd do. (G.W.R.) ...	26. 2. 17	do.
263rd do. ...	26. 4. 17	do.
264th do. ...	13. 5. 17	do.
265th do. ...	14. 9. 17	E.E.F. Egypt.
266th do. ...	14. 9. 17	do.
268th do. ...	19. 12. 16	B.E.F. France.
269th do. ...	17. 1. 17	do.
273rd do. ...	6. 9. 16	B.S.F. Salonica.
274th do. ...	23. 10. 16	E.E.F. Egypt.
275th do. (G.W.R.) ...	21. 8. 16	B.E.F. France.
270th Railway Labour Co., R.E.	15. 11. 15	B.S.F. Salonica.
271st do.	14. 1. 16	B.E.F. France.
30th Labour Battalion—		
A Co.	17. 5. 16	B.E.F. France.
B Co.	17. 6. 16	do.
C Co.	29. 6. 16	do.
D Co. and H.Q.	22. 7. 16	do.

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APPENDIX B.

COMPANIES SENT OVERSEAS FROM THE RAILWAY OPERATING TROOPS DEPÔT, R.E., ARE AS UNDER.

Designation.	Officers.	O.R.	Date of departure.	Expeditionary Force.
No. 1 Light Railway Operating	3	238	24. 1. 17	B.E.F.
No. 2 Light Railway Operating	3	231	4. 2. 17	do.
No. 18 Light Railway Train Crew	3	262	6. 2. 17	do.
No. 3. Light Railway Operating	3	228	9. 2. 17	do.
No. 19 Light Railway Train Crew	3	245	16. 2. 17	do.
No. 4 Light Railway Operating	3	232	23. 2. 17	do.
No. 6 Light Railway Operating	3	248	26. 2. 17	do.
No. 23 Light Railway Miscellaneous Trades	3	253	10. 3. 17	do.
No. 9 Light Railway Operating	3	254	12. 3. 17	do.
No. 10 Light Railway Operating	2	241	12. 3. 17	do.
No. 26 Light Railway Workshop	2	163	12. 3. 17	do.
No. 20 Light Railway Train Crew	3	252	18. 3. 17	do.
No. 37 Broad Gauge Miscellaneous Trades ...	2	204	21. 3. 17	do.
No. 21 Light Railway Train Crew	2	264	27. 3. 17	do.
No. 38 Broad Gauge Miscellaneous Trades ...	2	234	27. 3. 17	do.
No. 27 Light Railway Workshop	3	230	17. 4. 17	do.
No. 39 Broad Gauge Miscellaneous Trades ...	3	252	24. 4. 17	do.
No. 22 Light Railway Train Crew	3	224	7. 5. 17	do.
No. 12 Light Railway Operating	3	254	11. 5. 17	do.
No. 11 Light Railway Operating	3	262	17. 5. 17	do.
No. 24 Light Railway Miscellaneous Trades	3	222	17. 5. 17	do.
No. 14 Light Railway Operating	3	251	2. 5. 17	do.
No. 25 Light Railway Workshop	3	214	23. 5. 17	do.
No. 1 Electrical Section	1	25	15. 6. 17	do.
No. 2 Electrical Section	1	23	19. 6. 17	do.
No. 34 Broad Gauge Operating	3	252	21. 6. 17	do.
No. 3 Electrical Section	1	15	30. 6. 17	do.
No. 66 Wagon Erecting	2	215	30. 6. 17	do.
No. 79 Broad Gauge Workshop	3	218	10. 7. 17	do.
No. 80 Broad Gauge Workshop	3	179	23. 7. 17	do.
No. 67 Wagon Erecting	2	206	7. 8. 17	do.
No. 96 Light Railway Operating	5	241	2. 12. 17	E.E.F.
No. 98 Light Railway Train Crew	5	269	17. 12. 17	do.
No. 82 Broad Gauge Miscellaneous Trades ...	3	207	9. 2. 18	B.E.F.
No. 1 Platoon Transportation Stores Co. ...	2	60	16. 2. 18	I.E.F.
No. 1 Platoon 109th Light Railway Optg. Co.	2	67	18. 4. 18	I.E.F.
No. 86 Engine Crew	3	295	15. 11. 18	B.E.F.
No. 87 Engine Crew	3	201	24. 11. 18	do.
No. 36 Broad Gauge Operating	2	201	27. 11. 18	do.
No. 89 Engine Crew	3	246	5. 12. 18	do.
No. 55 Broad Gauge Operating	3	194	9. 12. 18	do.
No. 90 Engine Crew	1	218	27. 12. 18	do.
No. 68 Wagon Erecting	3	35	26. 1. 19	do.

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APPENDIX C.

ROAD CONSTRUCTION COMPANIES MOBILIZED AND DESPATCHED TO FRANCE AND EAST AFRICA.

Designation.		Strength Other ranks.	Date sent overseas.	
301st	R.C.C., R.E.	251	1. 1. 17	
302nd	do.	251	15. 1. 17	
303rd	do.	251	17. 1. 17	
304th	do.	251	22. 1. 17	
308th	do.	252	4. 2. 17	
309th	do.	251	4. 2. 17	
310th	do.	252	10. 2. 17	
311th	do.	251	11. 2. 17	
312th	do.	251	18. 2. 17	
331st	do.	247	1. 6. 17	
332nd	do.	247	12. 6 17	
333rd	do.	251	1. 3. 17	
334th	do.	251	1. 3. 17	
335th	do.	247	12. 3. 17	
336th	do.	247	16. 3. 17	
337th	do.	249	26. 3. 17	
339th	do.	246	12. 4. 17	
340th	do.	247	14. 4. 17	
341st	do.	247	24. 4. 17	
342nd	do.	247	27. 4. 17	
343rd	do.	247	3. 5. 17	
344th	do.	246	12. 5. 17	
345th	do.	246	24. 5. 17	
346th	do.	246	12. 9. 17	
347th	do.	246	26. 9. 17	
348th	do.	246	25. 10. 17	Quarry Co.
391st	do	11	3. 5. 18	To East
392nd	do.	11	3. 5. 18	Africa.
349th	do.	256	19. 7. 18	
	Total ... 29.			

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NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

No. 5.—*May*, 1919.

The German and French Cavalries in the Great War.

The article on the above subject by Colonel Poudret begun in the number of the *Revue* for March last, is continued in the number under notice. A brief examination is made of the French regulations relating to the employment of cavalry in dismounted action. The same principles, it is pointed out, apply in this case as those that govern the battle-tactics of infantry; however, cavalry, even in dismounted action, possesses greater rapidity of movement than infantry, and also mobility superior to the latter. The fullest advantage, it is laid down, should be taken of these characteristics of the cavalry arm, and a sufficient mounted reserve should be kept in hand in the early stages of the fight to exploit the success of the dismounted men. Colonel Poudret points out that a cavalry detachment intended to take part in dismounted action should be divided into three distinct groups:—

(*a.*) The dismounted men (organized in half-sections, sections, companies and battalions);

(*b.*) The led horses and the transport;

(*c.*) The mounted reserve.

The formation in which, it is suggested, the dismounted men should advance to the attack is briefly described in the original article, and the points to be attended to in the offensive and the defensive battle are also shortly stated.

The Great War has brought about some changes of opinion in relation to the rôle of cavalry as such, but the French High Command has shown by its use of cavalry that it believes that this arm can still effectively intervene in a modern battle, and to some extent as a mounted force. Emphasis is laid by Colonel Poudret on the following points:—

(*i.*) Whilst before the war the majority of soldiers had come to the conclusion that cavalry would normally be confined to reconnaissance work, the experience of the war has shown that such work can generally be more advantageously undertaken by the Air Force. On the other hand, contrary to anticipations, it has been shown that cavalry can continue to play an important part in a modern battle.

(*ii.*) The horses should be utilized to carry groups of men rapidly to the battlefield for dismounted action; later, during the battle, to transport these men to the flanks, or even to positions in rear of the enemy's line.

(*iii.*) Only in relation to the particular sphere of dismounted action have changes come into existence. Cavalry movements and other

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matters special to this arm remain unchanged and as they were prior to the war.

(*iv.*) The fundamental idea in cavalry dismounted action should consist in combining a frontal attack by dismounted men with a simultaneous attack of mounted men against the enemy's flanks: the concentrated fire of guns and automatic rifles being employed to assist the troops to gain the weak points (*i.e.* the flanks) of the enemy's line.

(*v.*) It is to be assumed that practically in every case that cavalry is required to go into action, it will be supported and assisted by guns, infantry supports, labour battalions, aeroplanes, armoured cars, etc., whether they form an organic part, or not, of important cavalry formations.

(*vi.*) Divisional cavalry should always be prepared to play a part on the battlefield.

(*vii.*) *Liaison* should play a capital rôle in every operation, and hence the diversity of the means employed to effect this purpose.—(*To be continued*).

THE BATTLE OF THE YSER.

The anonymous author of the original article calls attention to a work by Commandant A. Grasset, of the French Army, entitled *Préceptes et jugements du maréchal Foch*, extracts from which have been published in the number of the *Illustration* for March, 15th 1919. Commandant Grasset apparently claims in his work that many of the important decisions of the Belgian High Command were inspired by the distinguished French Marshal. The Commandant also states that it was owing to the intervention of Marshal Foch on October 20th, 1914, that the retreat of the Belgian Army on Dunkirk was prevented, and that later the scheme for inundating the Yser region was put in hand.

The author of the original article, whilst accepting the good intentions of Commander Grasset, expresses the opinion that the latter has based his account of the operations in the Yser region on erroneous and insufficient information, and has, in consequence, been led to exaggerate the part played by Marshal Foch and the French troops when co-operating with the Belgian forces which had escaped from Antwerp. It is pointed out that when the Belgian High Command brought the defenders of Antwerp to a halt on the Yser, it was made clear to them, in an Order of the Day issued by King Albert, that any man who retired from the position then taken up without a distinct order to do so would be held a traitor to his country. The battle opened on October 17th and continued till the 31st *idem*. On October 20th the Belgians, it is said, were holding on to their positions, extending from the sea to Noordschoote, with great firmness; no question of a retreat was in the minds of the Belgian High Command, nor was any Council of War held that day to discuss such a matter. On October 21st, as on the preceding day, the Belgians had to withstand violent German attacks and suffered heavily in casualties. In order to have reserves in hand on the important section of the front, Nieuport-Dixmude, the Belgian High Command asked the French High Command to take over a short section of the front south of Dixmude, so that the Belgian troops holding it might be moved north of the last mentioned place as reinforcements. The

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French Generalissimo acceded to this request, on condition that the Belgian right should maintain connection with the French troops holding Noordschoote. During the night of October 21-22, the Germans succeeded in crossing to the west of the Yser at Tervaete, and a French brigade was thereupon pushed into this neighbourhood. However, on the 24th *idem* the Germans succeeded in strengthening their hold on the west bank of the river at this point. On the 25th *idem* the French 42nd Division, at the time engaged near Nieuport, was moved south towards Dixmude, where the Belgians were very hard pressed. During the night of October 24-25, three Belgian battalions had repulsed 15 German assaults, and were practically worn out. The situation was becoming critical, and it was then that the Belgian High Command decided to inundate the region between the Yser and the Dixmude-Nieuport railway and ordered the preliminary measures to effect this purpose to be put in hand. The credit for the idea and for the execution of this scheme belongs, it is claimed in the original article, to the Belgian High Command. The Battle of the Yser was, it is said, a battle delivered and won by the Belgian Army. The victor on the Yser was none other than King Albert.

Art and the Army.

The original article refers to the lack of artistic taste shown in the designs appearing on certain official documents in use in the Swiss Army, such as diplomas, commissions, certificates, etc. They are lamentable examples of chromolithography, and few of the recipients of these documents have, it is stated, the courage to have them framed for decorative purposes.

A similar lack of artistic taste, it is stated, exists in relation to the Swiss soldiers' uniform. Complaint too is made of the music played by the regimental bands; some of the marches, it is said, are a cross between nigger-minstrel and cinema music, and set even the dogs howling. There has, however, been a revival in recent times in the matter of soldiers' songs, and songs which were the fashion long ages ago are being again rendered with taste by the soldiers of to-day.

There is room, it is urged, for art in military life.

Machine-Guns in Action.

The original article is an extract from a paper read by Capt. Bridel before the Société des Officiers at Lausanne. Therein he points out that infantry officers and young machine-gun officers should thoroughly familiarize themselves with the delicate mechanism of the machine-gun. He sets out briefly the sources of information on the subject open to Swiss officers. Regret is expressed that the military authorities have not distributed copies of the report made by the Swiss attachées who were with the belligerent armies more widely; it is suggested that every subaltern officer ought to have been furnished with a copy.

Particulars are given in the original article concerning the organization and equipment of a machine-gun company, its establishment, the

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various formations used in marching, etc. Extracts are also given from the Swiss Regulations bearing on the tactics of this new arm. The necessity for close co-operation between the infantry and machine-guns is indicated and it is pointed out that the configuration of the terrain is such in Switzerland as frequently to admit of employment of machine-guns in tiers.

Apparently, considerable progress has already been made in Switzerland in carrying out combined training with infantry and the machine-gun companies. Some stress is laid in the Swiss Regulations on the importance of not bringing machine-guns into action prematurely. The instruction on the subject runs: "He who has the courage to hold back his machine-guns till the last moment and to bring them into action at the shortest possible ranges, can reckon on certain success."—(*To be continued*).

NOTES AND NEWS.

Switzerland.—There are indications that military and labour unrest has invaded even Swiss territory; an infantry company appears recently to have mutinied at St. Gallen. The trouble has arisen owing to the relaxation in discipline.

The people of the Vorarlberg seem to be anxious to join the Helvetic Confederation as a canton (making the twenty-third). The matter is to be submitted to a plebiscite. The question as to whether it will be to the advantage of Switzerland to admit the people of Vorarlberg into the fold should they so desire is discussed. A certain section of the Swiss people are distinctly averse to any increase of the Germanic element in the composition of the Republic. But will it be wise for this section to veto the proposal?

The Ajoie forms a part of the proposed new canton, and General Maitrot has made a suggestion that the Swiss should cede this region to France; the reason being that it constitutes one of the keys to the "trouée de Belfort." The suggestion has upset the susceptibilities of a section of the Swiss press, which sees in it black designs against Switzerland on the part of France.

Rumour has it that Geneva is to be the International Headquarters of the League of Nations and this has given rise to questions affecting the defence of the proposed Capital of the League.

The death is announced of Colonel Emile Ruffieux and also of Colonel Sigismond Coutau.

Belgium.—A special correspondent writes that the whole of Belgium is a vast 'zone d'arrière,' and it would appear that the people are chafing under the restrictions in force which are still necessary as long as a state of war continues to exist. The question that seems to be of greatest interest to the public in Belgium at the present time is: What is to be the future of the Belgian Army? It is suggested that the present organization of the Belgian Army is only provisional and must soon be modified. In spite of the fact that the world is in travail and expects shortly to give birth to a League of Nations, Belgium, conscious of her experiences of 1914 is anxious to keep up an armed force of such dimensions in the future as will enable her to maintain her frontiers inviolate against all aggressors. It is recognized that the

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composition and organization of the new Belgian army will to some extent be governed by the demands made upon it in connection with the army of occupation in Germany: at the present time two Belgian divisions are co-operating with the Allied forces on the Rhine.

Information.

Switzerland.—A short article is published dealing with the question of Switzerland's neutrality in connection with the formation of the League of Nations. It is felt by many Swiss writers that owing to the tracing of the new frontier of France along the Rhine, Germany's shortest and easiest line of advance into the former country will now be *viâ* Switzerland. This situation is evidently disturbing the equanimity of certain students of military affairs who desire that the inviolability of Swiss territory shall be effectively guaranteed.

Bulletin Bibliographique.—Notices are published of the following works: *De la Marne à l'armée du Nord.* By General Berthaut (published by G. Van Oest et Cie of Paris and Brussels at 3fr. 90c.); *La décomposition de l'armée russe.* By General Nicholas de Monkevitz (published by Pagot et Cie of Paris and Lausanne at 4fr. 50c.); *France et Pologne. La paix française dans l'Europe orientale.* By General du Moriez (published by Pagot et Cie, Paris).

A list is also given of other new works received for review.

W. A. J. O'Meara.

Rivista di Artiglieria e Genio.

September, 1918.

German Light Maxim Mitrailleuse.

As is well known several armies were provided before the war with mitrailleuses usually fixed on tripods or other supports. Ordinary characteristics of these weapons varied with their weights from 20 to 25 kg., and their supports. Up to a period of ten years prior to 1914 trials were made, not with a view to the substitution of regular mitrailleuses, but by the addition of other arms of a lighter and more movable pattern.

In 1906 it became known that Denmark had adopted a really portable mitrailleuse (not to be confused with the automatic rifles used by some armies) as an armament for all the infantry. In 1905 the *Scientific American* gave a description of this new weapon, invented by the Danish engineer Schouboe, and perfected by General Madsen. The rapidity of its fire was about 180 shots a minute; and its weight only 7.5 kg. In addition to its use in the Danish army, where it was distributed to the cavalry, it was adopted by the Russians in the Russo-Japanese war. It was experimented upon in England, but was not adopted.

In 1907 trials were made in Austria with a light mitrailleuse called

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Salvenfeuer, weighing from 12 to 14 kg., and provided with a supporting prong or fork, but good results were not obtained as it was not further spoken of.

In 1909 the United States army adopted the light mitrailleuse Berrèt Mercié, a kind of portable Hotchkiss mitrailleuse, provided like the former with a stock and a supporting prong, and with a greater rapidity of fire of from 250 to 400 shots per minute. The fact that this army at the time of its participation in the European war hastened to substitute the Browning mitrailleuse shows that it did not place much dependence on the former weapon. The United States have also introduced into the service the light Lewis mitrailleuse, which is now principally used for aeroplane service in conjunction with the Marlin mitrailleuse. The external characteristics of the Lewis is the circulating loader placed horizontally below the breach, which gives the gun the appearance of a small cannon, although very light. It can be fired from the shoulder and is provided with a supporting prong.

In France in 1910 the munition factory at S. Étienne produced the light mitrailleuse or rifle-mitrailleuse Chauchat weighing 8 kg. and with a rapidity of fire of from 200 to 300 shots per minute; it was largely employed in the war.

Shortly after the commencement of the war the attention of all the belligerent states was concentrated on light mitrailleuses, and it may be noted that the solution of the problem of a very light mitrailleuse may be accorded to Italy. Under this point of view, Germany found itself at the commencement of the war in a less favourable condition, as its Maxim mitrailleuse of an old type was the heaviest weapon of its kind; it weighed in fact 26 kg., and with its carriage and mounting 56 kg.; other Maxims of more recent type were then tried, in which after many trials the weight was reduced to 22 kg. for the mitrailleuse and 34 for the carriage, but the enormous development of the use of mitrailleuses in this war, requires lighter weapons which can be placed in action anywhere and rapidly, and even by a single man. Germany only resolved the problem one half, reducing the weight of its Maxims by 3 kg. and abolishing the support.

The new light Maxim mitrailleuse is provided with a simple supporting prong, made with two short metal tubes, terminating below with a metal plate and point; the two tubes are fastened to the weapon near its central part. Instead of the usual stock this mitrailleuse is provided with a butt like that of a rifle, but of greater dimensions, so as to give a wide assistance to the shoulder. The trigger is like the butt of a pistol, and this allows for a firm hold with the right hand. The cartridge belt is attached to the right of the weapon. A conical tube is fixed at the muzzle, which serves to diminish the glare from the discharge. This light Maxim mitrailleuse—or rifle Spandau mitrailleuse as it is called from the name of the town where it is constructed—is similar to the German Maxim. The length of the new weapon is from 1.40 m.; the knee-piece when the prong rests on the ground is 28 cm. It will be seen that the solution by Germany of the problem of a really portable mitrailleuse is no better owing to the excessive weight of the weapon.

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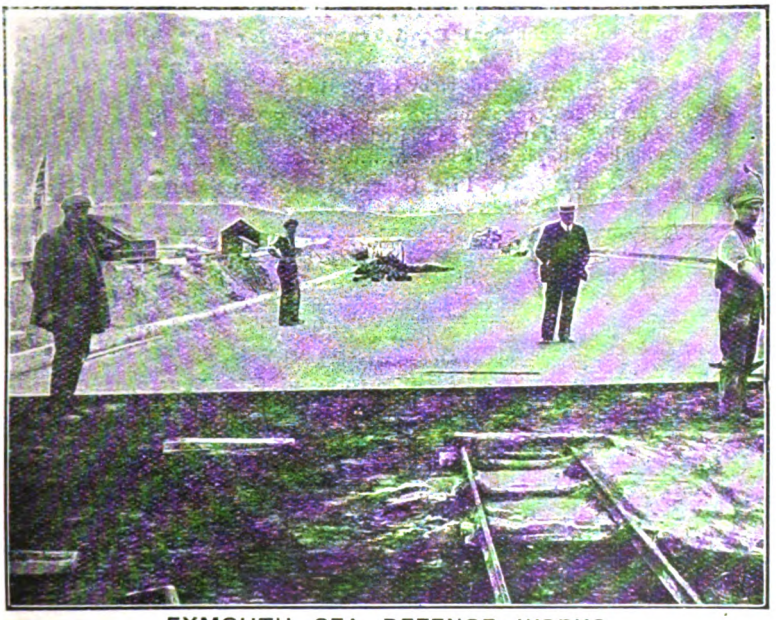

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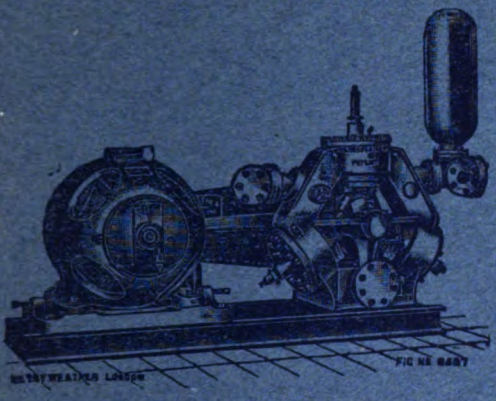

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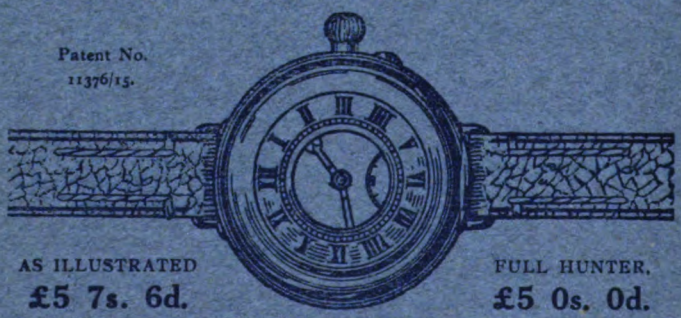

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Royal Engineers War Memorial Service.

A SERVICE " in memory of all ranks of the Royal Engineers who have given their lives in the service of their King and Country " was held in Rochester Cathedral on Tuesday, 22nd July. The number of Officers of the Corps who have fallen is 1,081, and of Other Ranks 17,833. His Majesty the King, Colonel-in-Chief of the Corps, was represented by Prince Arthur of Connaught, and the congregation included many distinguished soldiers and a large number of relatives and friends of the fallen. The service was solemn and deeply impressive, and was sweetened by the exquisite playing of the Band. One of the most solemn moments was when the people, at the Bishop's bidding, stood in silence, remembering, " with thanksgiving and with honour before God and man all ranks of the Royal Engineers who have died," and then kneeling, joined in the hymn " O valiant hearts, who to your glory came." The Dean of Rochester delivered a sympathetic and inspiring address. Quoting the motto of the Corps he pointed out how ubiquitous in the late war had been the call of duty and honour. Was it no consolation that the dead had not died in vain? This memorial service would have no true meaning for any man or woman unless it meant a fresh dedication of themselves to duty—duty to country and to home.

After the Benediction, pronounced by the Bishop, the " Last Post " was sounded, followed by the " Dead March in Saul." Then the Regimental Call merged into the Reveille, and the service ended with the first verse of " God save the King."

THEIR GLORY SHALL NOT BE BLOTTED OUT;
THEIR NAME LIVETH FOR EVERMORE.

Ecclesiasticus xliv., 13—14.

GOD PROVED THEM, AND FOUND THEM WORTHY OF HIMSELF.

Wisdom iii., 5.

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ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918

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Field Sqdns.		1, 2, 3		4th, 5th.				
Field Troops				3		7		
Field Cos.	414 (Lowland)	2, 5, 7, 9, 11, 12, 15, 23, 26,	54, 95, 101,	65, 66, 85,	17, 38, 99,	71, 72, 88.		
	415 (Lowland).	55, 56, 57, 59, 61, 62, 63, 64,	102, 128,	436 (Welsh),	100, 107,	448 (North'n.)		
	402 (Highland).	67, 68, 69, 70, 73, 74, 75, 76,	474 (S. Mid.),	437 (Welsh),	108, 127,	450 ,,		
	403 ,,	77, 78, 79, 80, 81, 82, 83, 84,	475 (S.Mid.),	484 E.A.,	131.	451 ,,		
	405 ,,	86, 87, 89, 90, 91, 92, 93, 94,	477 (S.Mid.),	486 E.A.,	420 (W.L.)			
	440 (Cheshire).	96, 97, 98, 103, 104, 105,	528 (D'ham).	495 Kt.,	449(North'n.)			
	441 (Glam.)	106, 121, 122, 123, 124, 126,		496 Kt.,	500 (Wessex)			
	442 ,,	129, 130, 150, 151, 152, 153,		519 Ln.,	501 ,,			
	485 (E. Anglian).	154, 155, 156, 157, 200, 201,		521 Ln.,	506 (Hants.)			
	487 ,,	202, 203, 204, 205, 206, 207,		522 Ln.				
	488 ,,	208, 209, 210, 211, 212, 218,						
	493 (H. Counties)	219, 222, 223, 224, 225, 226,						
	494 ,,	227, 228, 229, 231, 233, 234,						
	645 (W. Lancs.)	237, 247, 248, 249, No. 5						
	641 (North'n.)	(R.A.), No. 5 (R.M.), 400,						
	642 (London).	401, 404 (Highland), 406						
	643 (E. Anglian).	(Renfrew), 409, 410, 411,						
	644 (N. Mid.)	412, 413 (Lowland), 416						
	646 (London).	(Edinburgh), 419, 421, 422,						
	649 (W. Riding).	423 (W. Lancs.), 427, 428,						
		429, 430, 431, 432, (E. Lanc)						
		438, 439 (Cheshire), 446,						
		447 (North'n), 455, 456,						
		457, 458, 459, 460, 461 (W.						
		Riding), 465, 466, 467, 468,						
		469, 470, (N. Midland), 476,						
		478, 479, (S. Midland), 483						
		(E. Anglian), 490, 491 (H.						
		Counties), 497 (Kent), 502,						
		503, 504, 505 (Wessex), 509,						
		510, 511, 512, 513, 517, 518,						

In process of disbandment.

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ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.—*Cont.*

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	Mesopotamia.	East Africa.	Foreign Garrisons.
Field Cos. (*cont.*).		520 (London), 526, 527 (Durham), 529 (E. Riding), 546, 547(Kent), 549 (Lancs.) 550 (Glam.), 648 (H. Counties).						
Army Troops Cos.		20, 25, 42, 133, 134, 135, 136, 138, 141, 142, 144, 145, 146, 147, 148, 149, 167, 213, 214, 215, 216, 217, 221, 230, 232, 235, 236, 238, 239, 245, 280, 281, 282, 283, 284, 288, 289, 290, 7th (RM.), 552, (Aberdeen), 554 (Dundee), 556, 557 (Glam.), 559, 560 (Hants), 565 (Wilts), 567 (Devon), 573, 574 (Cornwall), 577 (Sussex)	158 (A and C Secns.) 285. 8 (Monmouth)	14, 35, 220 555 (Lancs.) 569 (Devon). 570 ,, 571 ,,	37, 137, 139, 140, 143, 286, 287			
Siege Cos.		1, 2, 4 (Royal Anglesey), 1, 4, 6 (Royal Monmouth).						
G.H.Q. Troops Co.		29.						
Electrical and Mech. Cos.		350, 351, 352, 353, 354, 355, 356				300		
Army Workshop Cos.		1, 2, 3, 4, 5						
Adv. Park Cos.		Adv. R.E. Parks: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12		389	4			

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ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	Mesopotamia.	East Africa.	Foreign Garrisons.
Base Park Cos.		1, 24, 32	246	13, 46	33	47		
Works Cos.	18, 34, 553 (Aberdeen). 561 (Hants). 562 ,, 563 ,, 564 ,, 566 (Wilts). 576 (Cornwall).	6, 22, 39, 572, 575, 578						558 (Glam) Gibraltar.
Artizan Works Cos.		51, 52, 58, 60, 159, 240, 241, 242, 243, 244, 1501, 1502, 1503, 1504, 1505, 1506						
Boring Secns.		1, 2, 3, 4, 5						
Fd. Survey Bns.		1, 2, 3, 4, 5 (" Depôt.")						
Fd. Survey Cos.			6	7	8		No. 6 Topo. Secn.	
Obs. Groups.		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 27	25, 29	28	26			
Sound Ranging Secn.	Exptl. Sound Rg. Observation Secn. (West Lavington).	A, B, BB, C, CC, D, DD, F, G, GG, H, I, J, K, L, M, O, P, R, S, T, U, W, Y, Z, " Experimental."	E.	N, NN, V.	Q, X.			
Inundation Secn.		1						

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ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	Mesopotamia.	East Africa.	Foreign Garrisons.
Reserve Survey Co.	19th (S/ton.)							
Anti-Aircraft Searchlight Secn.		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77	34					
Anti-Aircraft Searchlight Cos.	1, 2, 3, 4, 5, 6, 13 (Tyne), and 7, 8, 9, 10, 11, 12, 14, 15, 16, 17 (London).							
Field Searchlight Co.		50						
H.Q. and Depôt of Electrical Engrs.	Tyne, EE. London, EE.							
Emergency Secns.	1, 2							
Fortress Cos.	21, 30, 166. 590 Dundee. 591 Edinburgh. 592 ,,							616 Devon. Gibraltar.

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ORDER OF BATTLE OF R.E. UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.—*Cont.*

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	Mesopotamia.	East Africa.	Foreign Garrisons.
Fortress Cos. (*cont.*).	594 Edinburgh. 595 N. Riding 596 E. ,, 597 E. ,, 598 Kent. 599 London. 600 Cinque Ports. 602 London. 603 Hants. 604 ,, 605 ,, 606 Dorset. 607 Devon. 608 Cornwall. 609 Glamorgan. 610 ,, 611 Lancs. 612 Renfrew. 613 Lancs. 614 ,, 615 ,,							
Fortress Works Cos.	3, 16, 49 580 (Kent). 581 (E. Riding).							
Tunnelling Cos.		170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 250, 251, 252, 253, 254, 255, 256, 257, 258						
Water Supply Cos.				359, 360				
Water Works Co.				357				

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ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.—*Cont.*

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	Mesopotamia.	East Africa.	Foreign Garrisons.
Forestry Cos.		361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371						
Special Bde. Cylinder Cos.		A, B, C, D, E, F, G, H, J, K, L, M, N, O, P, Q.						
Special Bde. Mortar Cos.		1, 2, 3, 4						
Special Bdé. Projector Cos.		Z						
Depôt.	Reserve Mounted Depôt Aldershot Reserve Depôt, Sp. Bde., Devonport Reserve Met. Secn. (Stonehenge). 20th T.F. Depôt (Gillingham).	H.Q. and Depôt. Sp. Bde.						
Base Depôt.				1				
Camouflage School.	1 (Regents Park).							
Camouflage Park.	1							
Experimental Cos.	Exp. Tung. Secn. (Chattenden). Claremont Park Mun. Design Exp. Station, (Richmond)							

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ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.—*Cont.*

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	Mesopotamia.	East Africa.	Foreign Garrisons.
Experimental Stations (Sp. Bde.)	Wembley. Porton.							
Anti-Gas Estab.	1 (Gower St.)							
Meteorological Secn.	1	1	1	1 (included in Fd. Survey Co.)	1			
Depôt Cos.								
Groups of Depôt Cos.	No. 1, No. 2 (Chatham).							
Reserve Battalions	1 Chatham R.A.R.E 2 Chattenden, Beaumaris. 3 Newark, R.M.R.E. 4 Deganwy, Monmouth. 6 Irvine.							
Bridging Battalions.	1, 2, 3 and Hqs. Bdg. Training Centre.							
Pontoon Parks (H.T.)		1, 2, 3, 7	5	13				
Pontoon Parks (H.T.) (A.S.C. Units)		6, 8, 9 10 11, 12						

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.

Unit.	France.	Italy.	Egypt.	Mesopotamia.	N. Russia.	Salonika.	E. Africa.	Home.
G.H.Q. Signal Co.	G.H.Q. Sig. Co., included in "L" Sig. Battn.	G.H.Q. Sig. Co.	G.H.Q. Sig. Co.		G.H.Q. Sig. Co. Archangel Syren Sig. Co.	G.H.Q. Sig. Co.	G.H.Q. Sig. Co. (late Lindi Sig. Co.)	G.H.Q. Sig. Co.
Army Sig. Cos.	1st, 2nd, 3rd, 4th, 5th.							Special Sig. Co., Ireland.
Corps Sig. Cos.	A, B, C, D, E, F. G, L, N, O, P, R, S, T, X, Y. Tank Corps.	J. Corps Sig. Co.	U, V, W.			M, Q.		XXIII.
Cavalry Corps Sig. Sqdn.	Cavalry Corps Sig. Sqdn.							
Divisional Sig. Co.	Guards, 1st, 2nd, 3rd, 4th, 5th, 6th, 8th, 9th, 11th, 12th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 24th, 25th, 29th, 30th, 31st, 32nd, 33rd, 34th, 35th, 36th, 37th, 38th, 39th, 40th, 41st, 42nd, 46th, 47th, 49th, 50th, 51st, 52nd, 55th, 56th, 57th, 58th, 59th, 61st, 62nd, 63rd, 66th, 74th.	7th, 23rd, 48th.	10th, 53rd, 54th, 60th, 75th	13th	1st Archangel Div. Sig. Co. 2nd Ditto.	22nd, 26th, 27th, 28th.		64th, 67th, 68th, 69th Cyclist.
Divisional Sig. Sqdns.	1st, 2nd, 3rd.		4th, 5th.					

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit	France.	Italy.	Egypt.	Mesopotamia.	N Russia.	Salonika.	E. Africa.	Home.
Cavalry Bde. Sig. Troops.	1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 9th.		10th, 11th, 12th, 13th, 14th.					Cyclist Bdes., 1st, 2nd, 3rd 4th, 6th, 7th, 8th, 9th, 10th.
Infantry Bde. Sig. Secns.					236, 237, included in Syren Sig. Co.	228th.	Reserve Bde. Sec.	Nos. 221, 222, 223, 224, 225, 226, 227 (Mixed).
Air-Line Secns.	Nos. 5, 6, 7, 8, 9, 10, 11, 13, 16, 18, 19, 20, 27, 28, 29, 30, 31, 32, 33, 35, 36, 40, 43, 44, 45, 47, 48, 50, 51, 52, 53, 56, 64, 66, 70, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 100, 101.	Nos. 34, 54 and 102.	Nos. 21, 23, 24, 42, 68—all horsed. N.12, N.14, N.15. Nos. 61, 62, 69—all motor. No. 103 (British Indian). No. 105, ditto	22, 25, 63, 67, all horsed.		Nos. 1, 2, 3, 4, 38—all horse. Nos. 39, 60, 65—104 all Motor.	41, 46, 49 (included in L. of C. Sig. Co.)	T1, T2, T3, T4, T5, T6, 71 M.A.L. 72 M.A.L.
Sig. Construction Cos.	Nos. 1, 2, 3, 4, 5, 6.							
Cable Secns.	H, J, K, L, N, O, P, R, AA, AD, AK, AN, AP, AR, AS, AU, AW, AY, BD, BE, BF, BL, BM, BP, BT, BV, CC, EE, GG, GQ, LC, LZ, MM. OO, QQ, RR, SD, SS, SV, TT, VV, WE, TT, ZZ.	M, BU.	AG, AO, BQ, BR, BS, DC, GY, HH, KK, NA, NB, NN, UU.	BA, BC, BH, BJ, BX, DA, DB, FA, FB		AB, AE, AH, AJ, DK, DL.	AV, AX (included in other Units).	DF, DG.

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit.	France.	Italy.	Egypt.	Mesopotamia	N. Russia.	Salonika.	E. Africa.	Home.
Cable Secns. (*cont.*).	1 (3 Detachment) Sec. for Cavalry Corps.							
Area Sig. Detachments.	Nos. 1, 2, 3, 4, 5, 6, 7, 8, 8a, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40.							LA, DA, Sig. Co.
Light Railway Sig. Cos.	Nos. 1, 2, 3, 4, 5 (including Nos. 1 to 21 Maintenance Secns.)		No. 1 and No. Light Railway Sig. Secns.			Railway Telegraph Co		
Signal Schools	1st, 2nd, 3rd, 4th, 5th Army Schools Cavalry I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XIII, XV, XVII, XIX, XXII, Tank Corps.	Army Sig. School.	School of Instruction, Zeitoun. Two Corps Sig. Schools.	Army Sig. School, Baghdad.	Sig. School, Anhayeh.	Army Sig. School.		Army Sig. School, Dunstable.
L. of C. Sig. Unit.	The Sig. Bn. (including Nos. 1 to 6 Railway Telegraph Cos. and Nos. 1 to 5 Telegraph Construction Cos.) and Signal *personnel* at G.H.Q. and on L. of C.	L. of C. Sig. Co., No. 6 Telegraph Construction Co.	M (L. of C.) Sinai (L. of C.) South Palestine. L. of C. North Palestine. L. of C. Signal Cos.	No. 2 (L. of C.) Sig. Cos. River Wireless Sec.		(L. of C.) Sig. Co.	L. of C. Sig. Co.	

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit.	France.	Italy.	Egypt.	Mesopotamia.	N. Russia.	Salonika.	E. Africa.	Home.
Wireless Observation Groups.	No. 1 G.H.Q. Observation Group and Nos. 1, 2, 3, 4, 5, 6, Army Wireless Observation Groups.	No. 7 Army Wireless Observation Group.	No. 2 G.H.Q. Wireless Observation Group.	No. 4 G.H.Q. Wireless Observation Group.		No. 3 G.H.Q. Wireless Observation Group.		Wireless Observation Group (Home).
Sig. Base Depôt.	Sig. Base Depôt.		Headquarters of a Sig. Base Depôt for 500 men.	Signal Park and Depôt, Baghdad Advanced Sig. Park.		Sig. Base Depôt.	Signal Depôt.	S.S.T.C., Bedford.
Motor Wireless Secns.	Nos. 7, 8, Light Motor Wireless Secns.		Southern Motor Sec.	No. 5 Wireless Section No. 2 Lorry Station (included in 2nd L. of C. W/T Sqdn.).			No. 1 Motor Lorry, No. 1 Light Motor Lorry.	
Park Secns.			Nos. 6, 12 & London	Nos. 18, 19, 20, 21, 22, 23, 25, 31. (All included in No. 2 Wireless L. of C. Sig. Sqdn.)		Nos. 7, 8, 11 and 21.	No. 4. "A" Cavalry "B" Cavalry	No. 1.
Wagon Wireless Sec.			Northern No. 6, No. 9.			No. 5 Light Wagon Wireless Sec.	No. 4. Wagon Marconi Wagon.	No. 13.
Cavalry Wireless Sqdn.	1 for Cavalry Corps.		Desert Mtd. Corps Wireless Troop.	1st (Anzac). 2nd (L. of C.)				

"Wireless Signal Co."

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit.	France.	Italy.	Egypt	Mesopotamia.	N. Russia.	Salonika.	E. Africa.	Home.
Messenger Dog Service.	Central Kennels No. 1 Sec., No. 2 Sec., No. 3 Sec.							War Dog School.
Carrier Pigeon Service.	Carrier Pigeon Service.	Carrier Pigeon Service.	Carrier Pigeon Service	Carrier Pigeon Service.		Carrier Pigeon Service.		Carrier Pigeon Service.
Tank Group Sig. Cos.	1st, 2nd, 3rd.							
Tank Bde. Sig. Co.	1st, 2nd, 3rd, 4th, 5th, 6th.							
Army Field Artillery Bde. Sub-Secs.	5th, 14th, 16th, R.H.A., 5th, 11th, 14th, 18th, 23rd, 26th, 28th, 34th, 38th, 48th, 52nd, 64th, 65th, 72nd, 76th, 77th, 84th, 86th, 93rd, 96th, 104th, 108th, 113th, 119th, 126th, 147th, 150th, 155th, 158th, 169th, 175th, 179th, 189th, 232nd, 242nd, 277th, 282nd, 293rd, 298th, 311th, 315th.				6th R.F.A			

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit.	France.	Italy.	Egypt.	Mesopotamia.	N. Russia.	Salonika.	E. Africa.	Home
Rl. Garrison Arty. Bde. Sub-Secs.	Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 76, 77, 78, 79, 81, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 98, 99. Naval Siege Gun Sig. Sec.	Nos. 15, 24, 80, 94, 104.	Nos. 95, 96, 97, 100, 102, 103. No. 1 Heavy Artillery Sig. Secs. No. 2 Heavy Artillery Sig. Secs.			Nos. 20, 37, 61, 75, 82, H.Q. Heavy Artillery Sig. Sec.		
Sig. Co., with R.A.F. Independent Force.	One includes two Air-line Secs. and one Sig. Construction Co.							
Sig. Service Training Centre.								*Depôts:* Bedford A. Bedford B. Bedford C. Biggleswade. Fenny Stratford. Hitchin. Haynes Park. Wellingboro'. Cadet Battn.

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit.	France.	Italy.	Egypt.	Mesopotamia.	N. Russia.	Salonika.	E. Africa.	Home.
Sig. Secs. with Fortress Cos.								Forth Garrison (Nos. 591, 592); Clyde Garrison (No. 612); Tay and Aberdeen Garrison 590); Tyne Garrison (594); Humber Garrison (596 and 597); Tees Garrison (595); Thames and Medway (598 and 599); Dover Garrison (600 and 601); Harwich Garrison (21st); Newhaven Garrison (602); Mersey Garrison (611); Cardiff and Barry Garrison (609); Severn Garrison (610); Portsmouth Garrison 605; Plymouth Garrison (607 and 30); Portland Garrison (606); Fal-

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DISTRIBUTION OF SIGNAL UNITS ADMINISTERED BY W.O.—*Cont.*

Unit.	France.	Italy.	Egypt.	Mesopotamia.	N. Russia.	Salonika.	E. Africa.	Home.
Sig. Secs. with Fortress Cos. (*cont*).								mouth Garrison (608); Queenstown Garrison (614); Berehaven Garrison (615); Belfast and Lough Swilly (613).
Miscellaneous Units.							Reserve Heavy Cable Detachment. Reserve Motor Despatch Riders.	K. Sig. Co. Signals Experimental Establishment.

(R.E. RAILWAY AND ROAD TROOPS).

Unit.	Home.	France.	Italy.	Egypt.	Salonika	East Africa.
Depots.	R.E. Railway Construction Troops Depôt. R.E. Railway Operating Troops Depôt. R.E. Road and Quarry Troops Depôt. H.Q. Railways and Roads Trng. Centre.	D.G.T. Base Depot			Base Depôt.	
Military Railways at Home.	Military Camp Railways. Woolmer Instructional Military Railway.					

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ORDER OF BATTLE OF R.E. UNITS IN ALL THEATRES ON 11TH NOVEMBER, 1918.
(R.E. Railway and Road Troops).

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	E. Africa.
R.E. Railway Construction Cos.		8, 10, 109 to 114, 118, 119, 120, 259 to 264, 268, 296, 271, 275, 277, 278, 279, 280, 281, 282, 295 to 298. No. 3 R.A., R.E. (S.R.) Nos. 2 and 3, R.M., R.E. (S.R.)		115, 116, 265, 266, 272	117, 273, 267	
Railway Survey and Reconnaissance Secs.		1 to 7		106	108	
Railway Signal and Interlocking Co.		200				
Wagon Erecting Cos.		16, 17, 18, 66, 67, 70	One Sec.			
Broad Gauge Workshop Cos.		61, 62, 63, 78, 79, 80				
Broad Gauge Miscellaneous Trades Cos.		37, 38, 39, 82, 83				
Electrical Secns.		1, 2, 3				
Headquarters Secns. with A. Ds. L.R.		1 to 5				
Light Railway Operating Cos.		1, 2, 4, 6, 10, 11, 29 to 34	109 (one platoon only).	96, 203	107, 33	
Light Railway Train Crew Cos.		18 to 22		98		
Light Railway Forward Cos.		231, 232, 234 to 240				

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ORDER OF BATTLE OF R.E. UNITS IN ALL THEATRES OF 11TH NOVEMBER, 1918.

(R.E. RAILWAY AND ROAD TROOPS).

Unit.	Home.	France.	Italy.	Egypt.	Salonika.	E. Africa.
Light Railway Miscellaneous Trades Cos.		23, 24				
Light Railway Workshop Cos.		25, 26				
Light Railway Tractor Repair Co.		28				
Training Schools.		Light Railway Training School. Light Railway (Forward) Training School. R.O.D. Training School.				
Railway Traffic Secns.		1 to 13 Two Railway Traffic Secns. (Medn. L. of C.).	Three Secns. (not numbered).	Five Secns. (not numbered).	No. 1	
Broad Gauge Operating Cos.		1 to 7, 9, 11 to 15, 20 to 31, 34, 40 to 53, 64, 65		71 to 77, 94, 95, 99 to 105, 201 202	19, 32, 204	
Road Construction Cos.		301 to 319, 330 to 347, 349				391, 392 (nuclei only).
Quarry Cos.		198, 199, 320 to 329, 348				
Quarry Maintenance Sec.		1				
Steam Boiler Repair Co.		Not numbered.				
Transportation Stores Cos.	R.E. Transportation Stores Co., Purfleet.	1 to 13	Stores Secn.		Stores Park.	
Railway Labour Co.					270	

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Unit.	Home.	France.	Mesopotamia.	Egypt.
Depôts	H.Q. Richborough. H.Q. Southampton. H.Q. Poplar. H.Q. Richborough Depôt (Richborough). Sanitary Est. Depôt Co., 1—6 (Richborough.)	I.W.T., H.Q. Secs. 1—16, 24—27. B.E.F. Common to Army Areas and the Lines of Communication. H.Q. of O.C. I.W.T. Troops located at Aire.	Following at Basra :—H.Q., I.W.T. Depôt Headquarters of following formations :—Vessels, Marine Engineering, Accounts. Dockyards and Shipbuilding, Native Craft, I.W.T. Stores, Buoyage and Pilotage. Conservancy and Reclamation, Camps, Coal Depôt, Barge Depôt, H.Q. Construction (Bagdad), H.Q. Construction (Euphrates).	Cairo, Secs. at Port Said, Suez, Kantara Ferry, Port, Alexandria, Ismailia, Kerch & Assonar, Behera, Assiont, Menufer, Girga, Minia, Mansourah.
Workshop and Shipyard Cos.	H.Q. Richborough, 11—17 Richborough, 19—27 Richborough, 37—40 Richborough, 43—48 Richborough.	*Docks :* No. 1 H.Q. Boulogne. No. 2 H.Q. Havre. No. 4 H.Q. Calais. No. 5 H.Q. Dunkirk. No. 6 H.Q. Dieppe.		M.L.O.C. Taranto.
Construction Cos.	H.Q. Richborough, 96, 97 Richborough, 98 Poole, 99 Southampton, 100—103 Manston, 104 Poole, 105 Hawkings, 106—108 Amesbury, 109 Lulworth, 116 Poole, 117, 118 Richborough, 119 Slough, 120 Farlington, 121 Amesbury, 122 Poole, 131, 132 Richborough, 136 Richborough, 141, 142 Richborough.	Docks, Cherbourg. No. 8 P.C. Co. R.E., Boulogne. No. 11 P.C. Co., R.E., Havre. *Port Construction Cos.:* C.E.P.C., H.Q. D.G.T., G.H.Q. No. 1 P.C. H.Q. Dunkirk No. 2 P.C. H.Q., Rang-de-Fliers. No. 3 P.C. H.Q., Oissel-Rouen. No. 1 P.C. Co., Lery. No. 2 P.C. Co., Quevilly y Rouen. No. 6 P.C. Co., Oissel-Rouen. No. 4 P.C. Co., Rang-de-Fliers. No. 5 P.C. Co., Les Forts-Bergues.	DETACHMENTS AT THE FOLLOWING PLACES — *Camps :* Margil, Khora Creek, Tancoma (Abadan) NARROW SECTION:—Ezraz's Tomb Gumaijah Shargi South Station, Michriya C. Stn. Central Stn. Quadat Saleh, Majar Kahir, North Station, Ali Charbi, Sumar. BAGHDAD SECTIONS:—Zeur, Hinaidi, Advanced Base, Baghdad, Sadieyeh, Akab, Samarah, Diala, Baguaba. *Persian Lines of Communication :* Karun, Ahwaz, Muscat. UPPER EUPHRATES : I.O.V. and I.M.E. Dhibban, Riverhead, Hit, Ramadie, Madij, Abu Huyat, Uqbah, Feluja, I.W.T.O. MIDDLE EUPHRATES ; Hillah, Iseurieriyen, Musayib, Tawerij, Kufa, Hindia, Barrage, Magranal Delha and El Hassam, Jebeira,	EAST AFRICA. Port Amelia, Mozambique, Lindi, Dar-es-Salaam, Kilindini. RUSSIA. Murmansk.
Marine Cos.	H.Q. Richborogh, 70—75 Richborough, 76 Poplar.			
Traffic Cos.	H.Q. Richborough, 56—61 Richborough,			
Train Ferry Cos.	H.Q. Richborough, 85, 86 Richborough, 87, 88 Southampton.			
T.F. Shore Co.	62 Southampton.			
Stores Cos.	H.Q. Richborough, 90—91 Richborough.			

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ORDER OF BATTLE I.W. & D.—*Cont.*

Unit.	Home	France.	Mesopotamia.	Egypt.
Accounts Co.	95 Richborough.	No. 6 P.C. Co., Dunkirk. No. 7 P.C. Co., Ostend.	Madhetia, Jerboyian, Zenafiah, Daghara, Jellan, Afaij, Ebra, Khan, Jadwal, Diwanieh, Imam Hamzah, Rumetha, Hamadieh, Gus, Kifl, Shamiyeh, Chemas, Abu Sakair, Kala Abasiyah. LOWER EUPHRATES: Durraji, Samawah, Nasseriyeh, Waar, Shenafiah.	
Mesopotamia Reserve Unit.	Glasgow.			
Marine Co. (Scottish Canal).	144 Glasgow.			
Craft Repair Co.	77 Poplar.			
Home Depôt.	Richborough.			
Tugmasters	Richborough.			

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AN INFANTRY CORK FLOAT FOOTBRIDGE AND LIGHT IMPROVISED FERRY BOAT.

By BRIG.-GENERAL E. N. STOCKLEY, D.S.O., Chief Engineer, XIX. Corps.

BRIDGING operations on the Western Front in the final phase of the war, during which successive canal and river crossings were made, showed that the crossing of a river by an Army may be divided into four stages :—

(*a*). The crossing of the Infantry Patrols, Covering Parties, and Advanced Troops by improvised light boats and foot bridges.

(*b*). The crossing of the Field Artillery and Divisional horsed transport, motor cars, and light motor ambulances, by the medium pontoon bridges.

(*c*). The crossing of the Corps Heavy Artillery with Caterpillars, Ammunition and Supply lorries, and other heavy transport, by the super-heavy pontoon raft-bridges with steel joist super-structure.

(*d*). The substitution of heavy trestle or steel girder bridges for the heavy pontoon bridges, and release of all portable equipment, for the next river crossing.

Of these, (*a*) being the first and tactically the most important it is very desirable that standardized equipment should be ready, and the sappers, who are to use it, drill-perfect. No universal pattern for this equipment has yet been worked out, and many different forms have been improvised from petrol cans, metal floats, straw bundles, timber and canvas floats, etc. The object to be aimed at is extreme portability, as these crossings must be made at many points, and usually at a distance from the recognized approaches, which are sure to be heavily shelled. The equipment must therefore stand some handling, and it is of the greatest importance that the float should not be rendered useless by a chance bullet.

The lightest and least vulnerable pattern evolved is probably the Cork float bridge, and the pattern made up in the temporary Corps Workshops and issued to the three Divisions of this Corps for the crossing of the R. Scheldt, after practice on the R. Lys

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at Courtrai, may give some useful ideas to those whose duty it may be to evolve the best universal pattern for future use. Two men can carry the float some distance across country, and a third the light 10-ft. bay of bridge to lay on the saddle. A river 120 ft. wide can be spanned in four or five minutes, if all stores come up in a consecutive stream as required, and only four men need be exposed simultaneously on the bank to boom out the bridge.

A N.C.O. of the Corps should remain in charge to check the tendency to overcrowd, and see that a two or three yard interval is kept by the Infantry, and four sappers should remain at hand with a spare float and bay in case of any break occurring. It is considered that four such bridges, each 120 ft., should be carried by a Divisional Bridging train in addition to its pontoon equipment.

Plate I. shows the design of the Cork Float Bridge.

A useful type of light improvised portable boat was designed by the field companies of the 35th Division, and used by all three Divisions in the same operations. This was made from the waterproof trench shelter sheet, measuring 13 ft. × 10 ft., folded and tied on a light wooden frame, and proved of great value for the first crossing of the Infantry Patrols, and for subsequent continuous ferrying. At least eight such boats should be carried, each with a pair of light oars and a bailer, and enough cordage to use them as ferries on return trips. The sheets require additional waterproofing if much used. There should be a sapper in each boat to act as boatman and one on each bank to tend the rope.

Plate II. shows the design of the boat.

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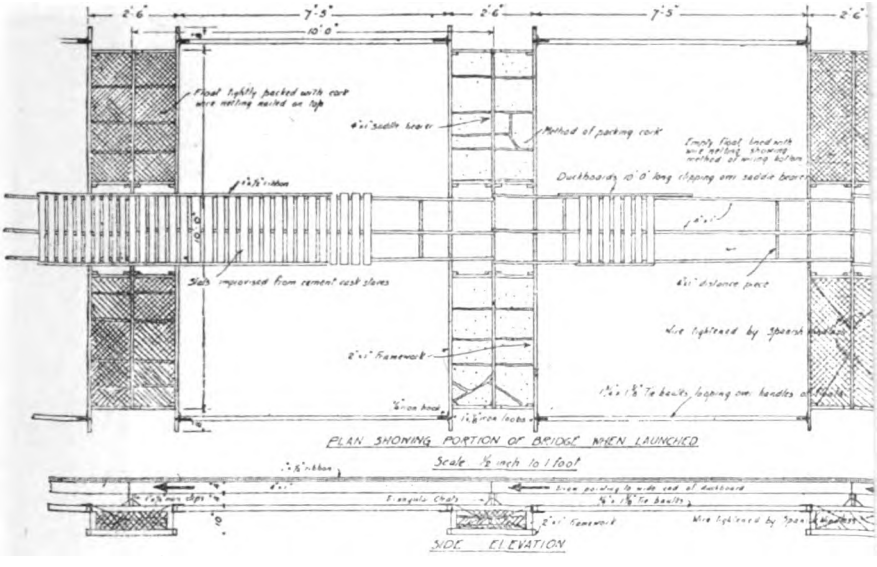

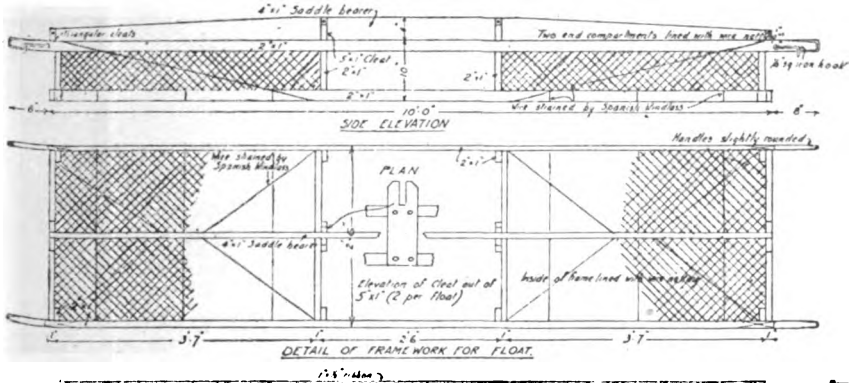
4"x1" Saddle bearer
Two end compartments loaded with wire netting
10'0"
Wire strained by Spanish windlass
SIDE ELEVATION
Handles slightly rounded
PLAN
Elevation of Cleat out of 5"x1" (2 per float)
DETAIL OF FRAME WORK FOR FLOAT.

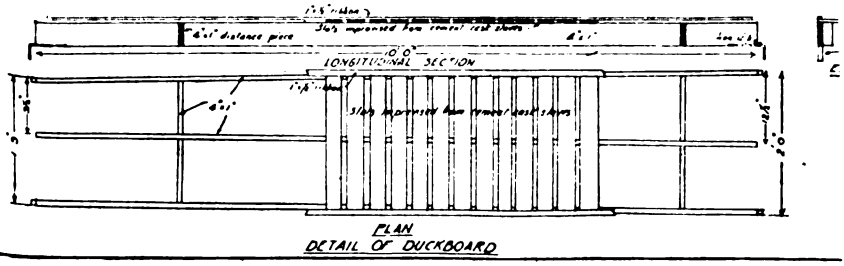

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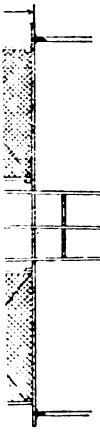
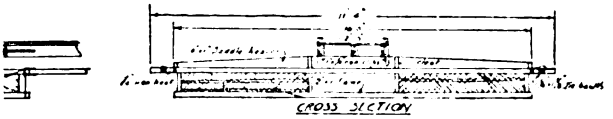
PLATE I.

CORK FLOAT FOOTBRIDGES

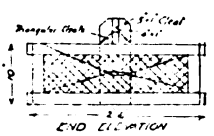


NOTE The following material is required in addition to that shown on sketch
2 - Launching ways 10'0" x 3" x 2"
2 - Stringers 5'0" x 3" x 2"
10 - Pickets 3'0" x 3" x 2"
4 - 8 Manila Lines 60'0" long
2 - 1" " " "

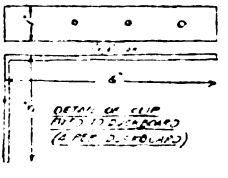
Scale for Details of Woodwork - 1" to 1'
Scale for Details of Ironwork - 3/4" to 1'



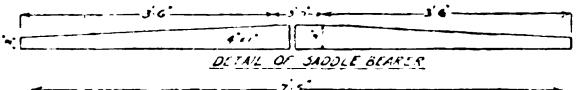
CROSS SECTION



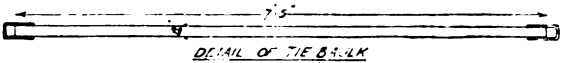
END ELEVATION



DETAIL OF CLIP
(12 PER FLOAT)

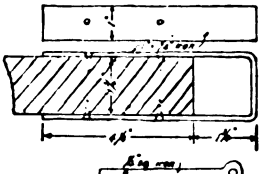


DETAIL OF SADDLE BEARERS

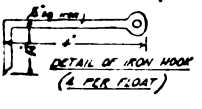


DETAIL OF TIE BAULK
(1 PER FLOAT)

NO ELEVATION



Detail of Iron Loop attached to the Baulk (2 per Baulk)



DETAIL OF IRON HOOK
(4 PER FLOAT)

C.E.
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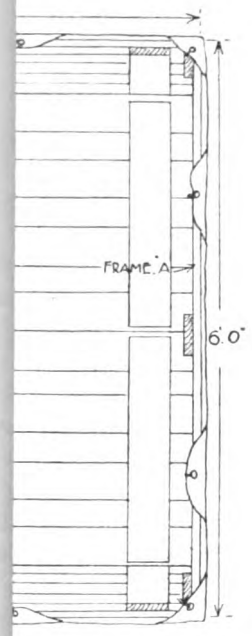
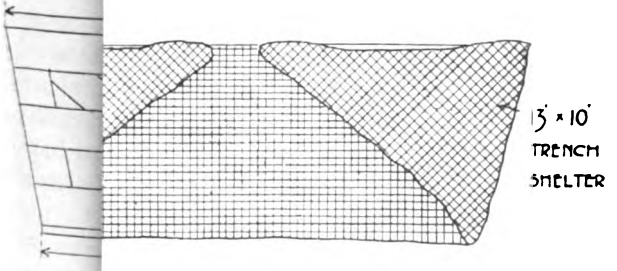
PLATE II.

...AT.

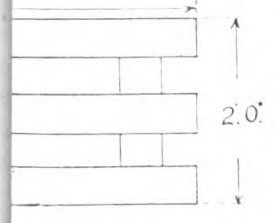
...form as

...ted.





ELEVATION



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A FIELD BLONDIN ROPEWAY AS AN AID TO BRIDGING.

By CAPT. (ACTING MAJOR) I. SIMSON, R.E.

IN September and October, 1914, the 8th (Railway) Co., R.E., had to construct two railway bridges in France, and made use of a Field Blondin Ropeway for launching the girders and dropping the various component parts of the bridge into position.

Such a Blondin Ropeway is still of great use for railway construction even when high capacity and long reach cranes are available. It is very quickly erected from material usually available in the field. Its capacity—if constructed of telegraph poles and 3½-in. rope—is probably limited to about two tons, but by lifting only one end of girders, etc., at a time this means that about 4-ton loads can be handled and this is generally sufficient. The " reach " of such a ropeway is practically unlimited, exceeding that of any crane; it spans the whole of a normal gap, and from the moment it is erected it can be employed continuously for clearing away the débris of the old bridge, running out concrete, etc., for foundations, dropping complete trestles (built on shore) into position if not too heavy, launching the girders, etc. It enables work to proceed, if required, on the whole length of a bridge simultaneously, instead of only on one or at most two spans at a time. Its principles of operation may thus prove of service in all types of field engineering, but its use is of course limited in the case of bridges built on curves.

The diagram shows the actual detailed arrangement of the Blondin, as erected in the particular cases referred to. Each pair of sheer legs consisted of two locally acquired telegraph poles 50 ft. to 56 ft. long, butts about 11½ in. diam. and tips 6 in.; the feet of each sheer leg being spaced 13 ft. apart so that a railway truck with material could be run under the legs, and the material picked up direct off the truck by the lifting tackle. The sheers themselves were about 120 ft. apart. The runner, travelling, and lifting tackles, and both back guys consisted of 3½-in. to 4-in. Manilla rope, which was available in coils of 113 fathoms. No blocks with more than 3 sheaves were available at the time. Lashings were of 2-in. rope throughout, while ¾-in. chain was used in addition at each crutch, to couple direct the blocks of the runner tackle and back guys. Side guys of 3½-in. rope were also employed (not shown in diagram).

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The arrangement of blocks shown had the following advantages :—

(*a*) Equal strain in all returns of each back guy and " runner " tackle.

(*b*) Easy adjustment for the considerable stretch that took place in all back guys and runner tackle. (The ropes were all new and had never been used previously).

(*c*) By paying out on Q (not under load) the strain on the " runner " tackle was reduced to a minimum for heavy loads ; the " runner " tackle being then at a very steep angle instead of approaching the horizontal, and the blocks of the lifting tackle being chock-a-block when the weight was lifted as high as necessary.

The sheer legs had the great advantage of being self erecting and required no subsidiary derrick poles or tackles to get them up. The legs were placed opposite their footings, both crutches lying away from the gap. One sheers (B) was lashed down to the railway track temporarily ; while the crutch of sheers (A) was raised on to a sleeper crib built up on a railway truck—the crutch thus being 12 ft. or so above rail level—and the feet tied back temporarily to the track. By pulling on the runner tackle in the direction Q1 (from the side " B " of the gap), sheers " A " was pulled up and its back guys made fast when " A " was leaning well forward over the gap.

The free end of the runner tackle Q1 was then run over the second pulley of the double block at the crutch of sheers " B," and, by pulling in the direction Q2, sheers " B " was raised. When also leaning well forward the free end (R1) of the back guy for " B " was made fast, and the free end (Q2) of the runner tackle run through the snatch block (at foot of sheers " B "), in its final direction Q, in which it was made fast. The legs were adjusted for verticality by taking in or paying out on R1 and R2. The runner tackle was adjusted to suit by paying out or taking in Q. The operation of lowering was carried out by practically reversing the above process.

Photograph No. 1 shows the Blondin Ropeway in operation at Pont de Metz (near Amiens), a 53-ft. clear span (elliptical brick arch), destroyed by the enemy, and repaired September—October, 1914. All the timbers in the central trestle and the roadbearers (maximum weight of a single piece about $1\frac{3}{4}$ tons) were dropped into position by the Blondin. *Photograph* No. 2 shows the completed bridge.

Photographs Nos. 3, 4, 5 and 6 show the Blondin at work launching 34-ft. steel girders for the new railway bridge over La Bresle River at Longroy Gamaches (October, 1914). These girders weighed about 3 tons each.

The general procedure for launching the girders was as follows : The truck carrying the girders was run up to the edge of the gap.

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A FIELD BLONDIN ROPEWAY AS AN AID TO BRIDGING.

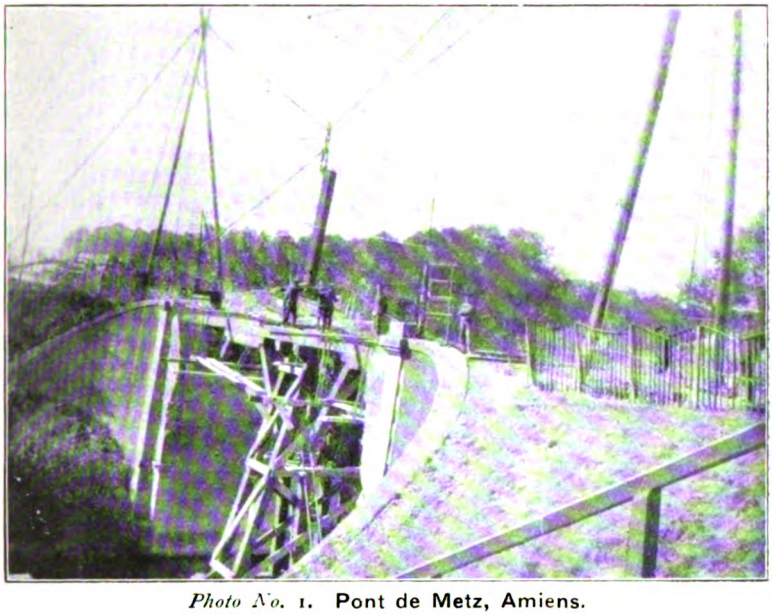

Photo No. 1. Pont de Metz, Amiens.

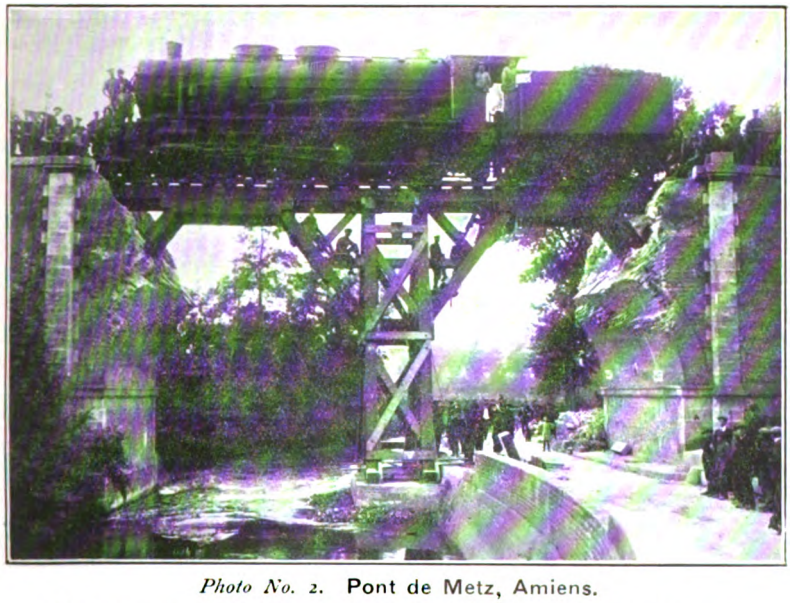

Photo No. 2. Pont de Metz, Amiens.

Reconstructed Bridge, under test for deflection with Nord Railway 2–8–0 locomotive; weight about 125 tons.

Note :—The original bridge was a single span, over both roadway and stream.

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A FIELD BLONDIN ROPEWAY AS AN AID TO BRIDGING.

Photo No. 3. La Bresle River, Longroy Gamaches.

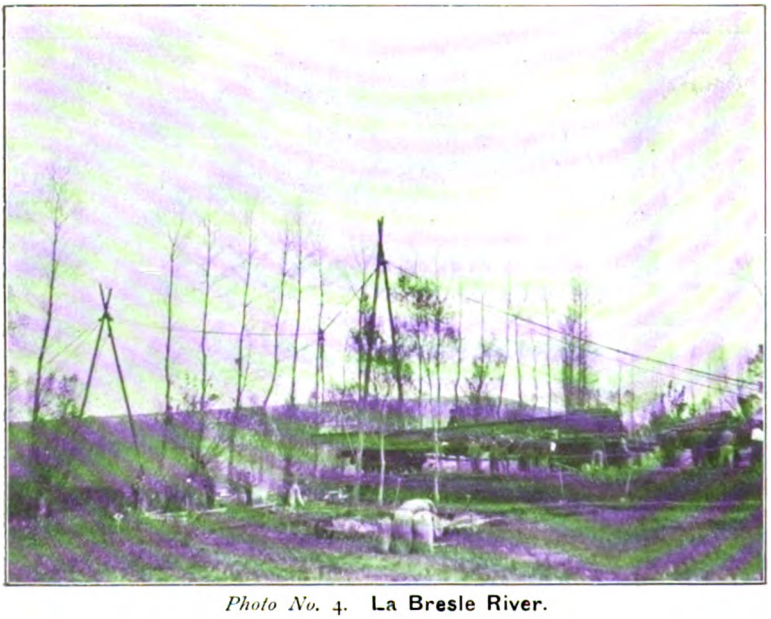

Photo No. 4. La Bresle River.

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A FIELD BLONDIN ROPEWAY AS AN AID TO BRIDGING.

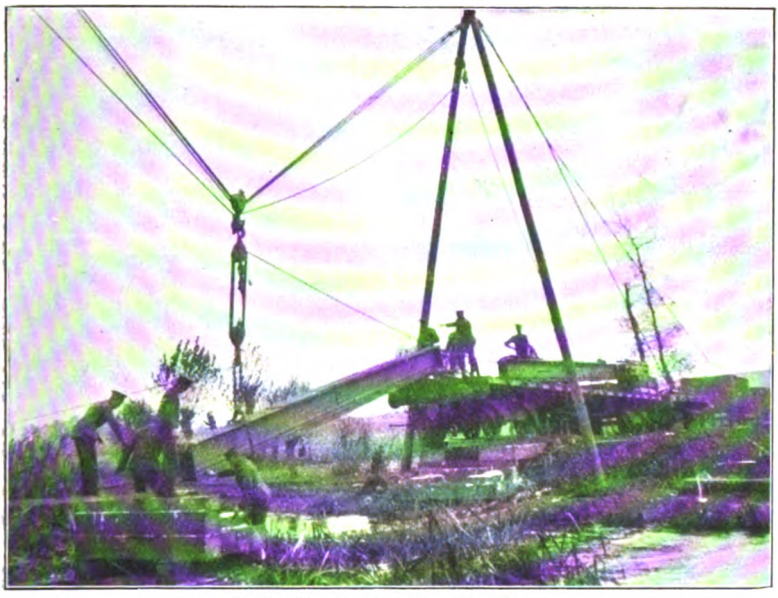

Photo No. 5. La Bresle River.

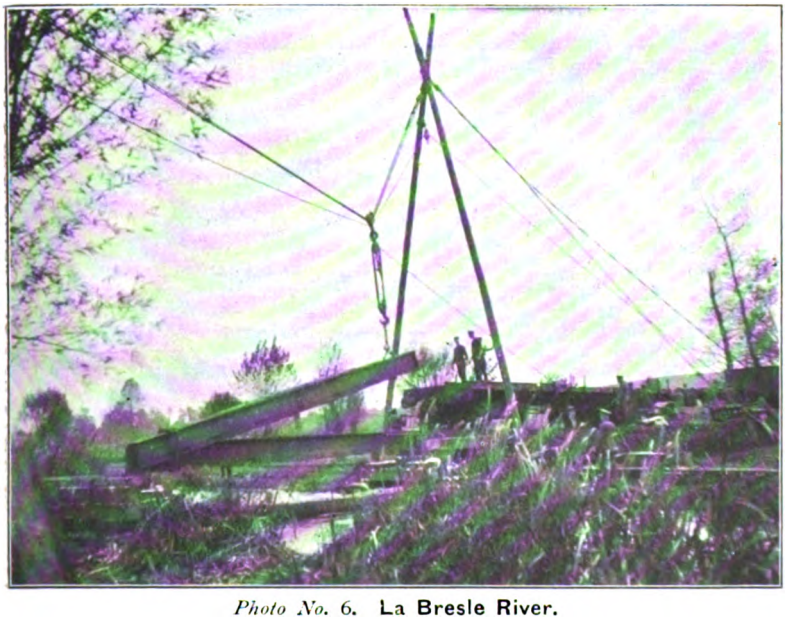

Photo No. 6. La Bresle River.

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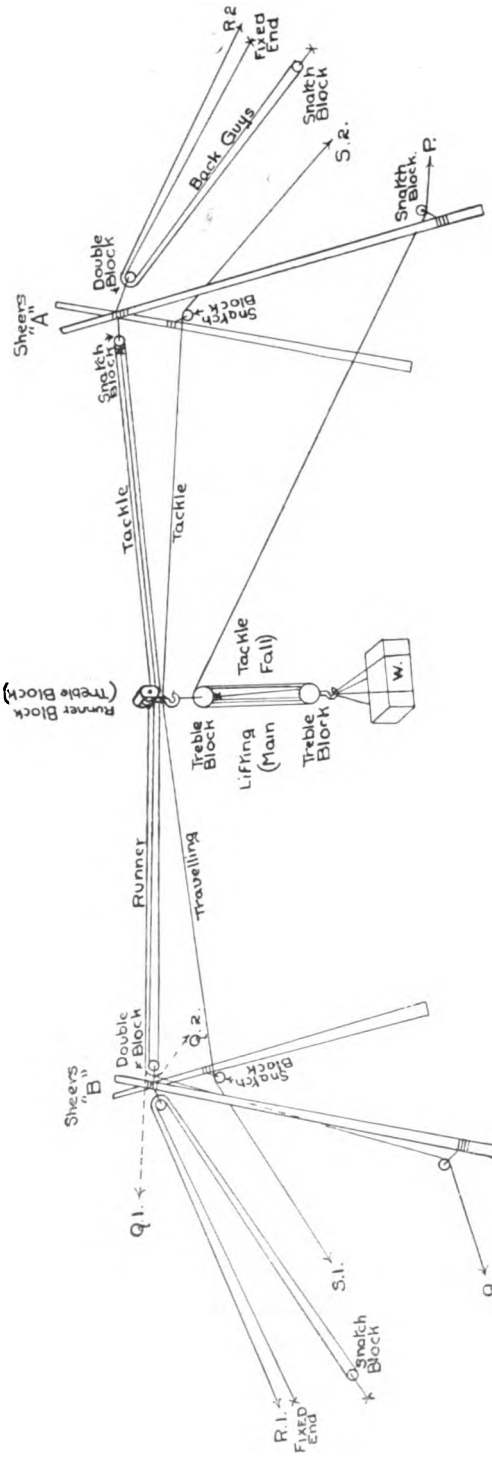
A FIELD BLONDIN ROPEWAY AS AN AID TO BRIDGING.



Field "Blondin" Ropeway
Shewing Arrangement of Tackles.
x Denotes fixed end of rope in any tackle.
+ Denotes free end of a tackle by means of which adjustments could be made.

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The front end of the girder was picked up by the tackle, which was then hauled forward on the runner, the back end of the girder being pinched forward on the truck (*Photos* Nos. 3 and 4). The front end was then lowered on to its abutment, the back end resting on the edge of the truck (*Photo* No. 5). Next the back end was picked up by the tackle (*Photo* No. 6), the truck run back out of the way, and the girder dropped into position. It will be noted that at no time during the operation did more than approximately half the weight of the girder come on the gear.

In the construction of this bridge, the four telegraph poles, cordage, etc., were unloaded from railway trucks, lashed and erected, the girders launched, cross-braced, the track laid across the bridge and three small shore spans, and the Blondin dismantled and loaded up again, in 11 hours by 10 sappers, assisted by 30 unskilled refugees.

In conclusion it is pointed out that sheer legs "A"—on the side of the gap to which material can be brought by rail or road—should be situated as near the edge of the gap as possible consistent with picking up the loads directly (off a railway truck or lorry run between the legs); and the running end (P) of the main fall should be run off on this side of the gap. Sheers "B" should be situated as far from the edge of the gap as length of cordage will allow. The object of this is to get the far end of the bridge near the centre of the Blondin span. *All* loads then run *down* the runner tackle, till at the centre of the Blondin span they are at their lowest point. If they have to go further than this, the loads must then be pulled *up* the runner tackle by means of S1. Steel cable for the runner tackle would undoubtedly prove a great improvement for such a Blondin, but was not available at the time.

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REINFORCED CONCRETE LORRY TRACK.

By BT. COLONEL H. L. PRITCHARD, C.M.G., D.S.O., R.E.

ANYONE who has been asked to produce a road "forthwith" to carry long convoys of the service 3-ton lorries knows the difficulties of the undertaking.

The 3-ton lorry used in our service, weighing as it does seven tons when loaded, of which five tons are on the back axle, acts like a 5-ton pile driver on the road, which must be a first-class one to stand the traffic for long.

The Italian Army Engineer is more fortunate. His Government use a F.I.A.T. lorry, weighing when loaded about $2\frac{3}{4}$ tons, of which the load is nearly $1\frac{1}{4}$ tons. Driven by Italian drivers at break-neck speed round hairpin bends on the wrong side of precipitous mountain roads, it delivers its load twice without damaging the road, while our lorry pile-drives its way once through to its destination and then struggles to return over the obstacle-course it has created.

Anticipating urgent calls for lorry roads during an advance, and the material for wood "slab" roads not being available where required, experiments were made to secure a stock of reinforced concrete rails and sleepers (see *Plates*). Sufficient experiments were made to convince the writer that these would be invaluable in the emergency contemplated, although for reasons with which this article is not concerned, I cannot produce proofs of its use on any extensive scale.

The main purpose of this reinforced concrete lorry track is to ensure a passage for lorries over those portions of a road which are threatening to become impassable, and to gain time for a more thorough reconstruction of the route that is being used if it is likely to develop into a permanent road. There are many roads which will remain passable for some considerable length of time if one can repair portions, which perhaps aggregate 20% of the whole length, so that a stock of 10 miles of this concrete track might guarantee say 50 miles of road for a considerable period. The track should be ballasted flush with its surface with the best material locally obtainable, but even if this is bad material the concrete track is still of use, as lorry drivers find no difficulty in keeping on it, though it then becomes like a single line of railway as regards

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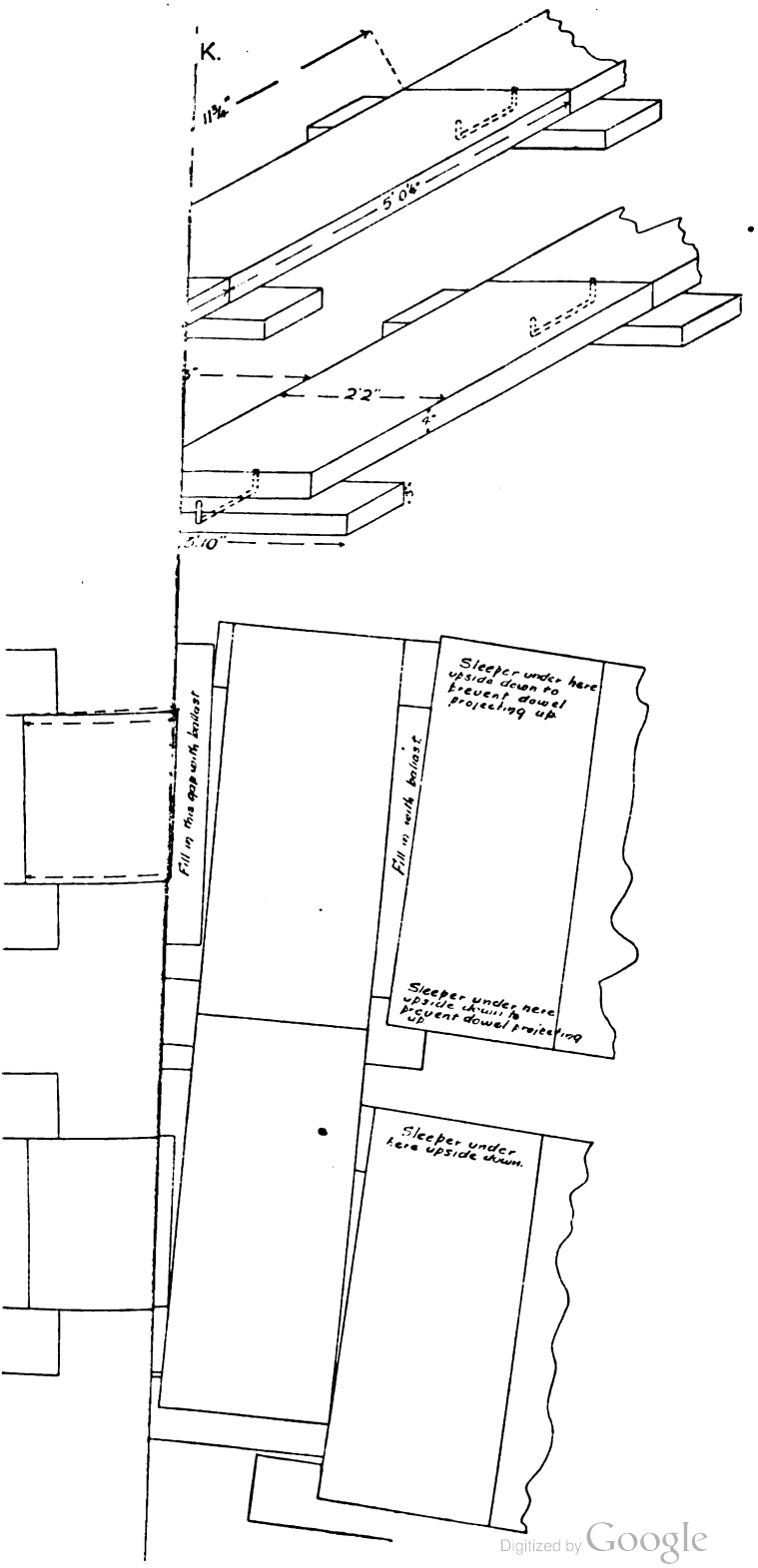

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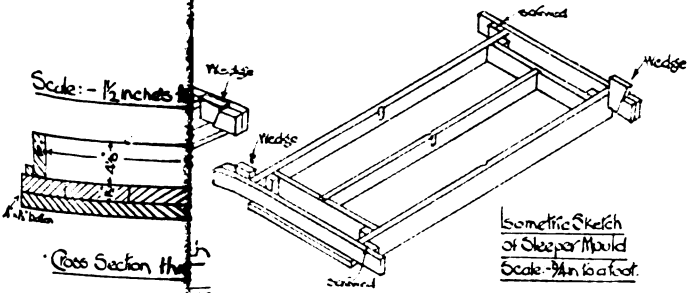
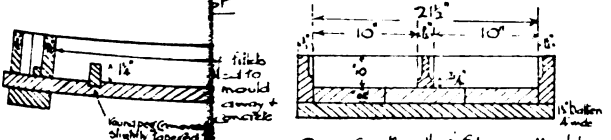
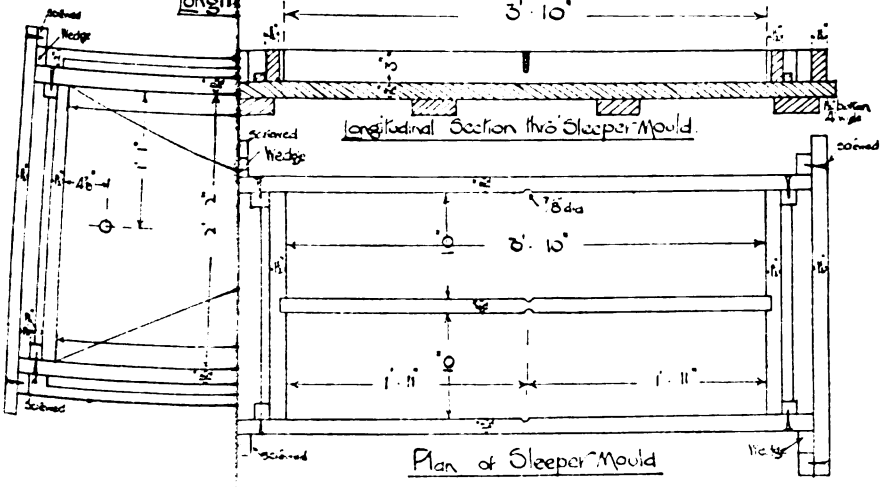
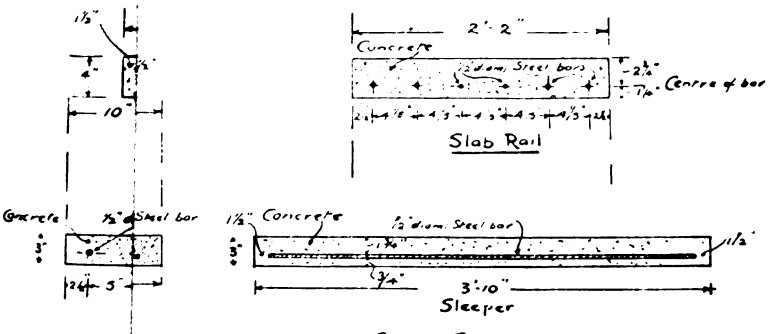
OF WOOD MOULDS.







DETAIL OF REINFORCEMENT



NB If Steel Bars are re
3 layers in Slab Ra
above each other ar
of sheets to be 1 in

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traffic control. As, however, passing places can be arranged at frequent intervals on the good portions of the road or by laying double track, the traffic control difficulty is not insuperable.

The transport required to bring this track to site, as compared with what is required for soleing and metalling a lorry road, is overwhelmingly in favour of the concrete track. Some of the slabs may crack or even break, but even in this condition they remain serviceable for a very long time. Like the permanent way of a railway they can be taken up from one route and relaid on another.

Examination of the drawings will show that one side of each rail is longer than the other, 4ft. 11¾in. as compared with 5ft. 0¼in. This enables the track to take easy curves to right or left, while for laying straight track, long and short sides of rails are laid alternately outside. To negotiate sharp curves the whole curve can be paved and widened by laying the rails radially at right angles to the direction of the track and filling interstices with road metal, but in this case the sleepers must be laid with the projecting dowel downwards as the recesses in rails to receive dowels do not come in the right place when rails are laid in this way. Lorry parks can be paved quickly with these concrete slabs.

Light portable swinging derricks each with a horizontal arm carrying a travelling differential tackle (as supplied with pontoon equipment) were made, suitable for erection either in a lorry or on the ground, for the purpose of loading and unloading the concrete slabs into and out of lorries and on to a railway porter's barrow in which they could be wheeled along the track to the head of it. "Cramps" suspended from the tackle seized the slabs.

The drawings show the slabs reinforced with steel rods, which are probably better reinforcement than expanded metal, but the slabs which were actually tested were reinforced with expanded metal. The drawings shewn in the *Plates* were prepared when it was decided to change to rod reinforcement, but none of the latter type were actually made and tested.

A track of these concrete rails and sleepers was laid across a dry river bed on a road leading into an R.E. dump, into which at least fifteen lorries ran daily for eight months. Some of the slabs remained quite undamaged, others though damaged still served their purpose. With practice and care in manufacture the percentage of slabs failing would be small.

It is suggested that this system meets an emergency that often arises and that it is wise to store some miles of the track ready for the emergency in any area in which operations are proposed, if the country is not served by good lorry roads.

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JOTTINGS BY A C.R.E.

ABOUT the middle of August, 1914, recruiting for all branches of the 1st Australian Division started at Sydney. The press of recruits was enormous. Lieut. King had charge. One morning they rushed the front gates and invaded the barracks. King handled the situation neatly, ordered the men to form up smartly and show themselves soldiers. He then marched them out of the barracks by the back gate and closed it behind them. The men saw the joke against them and took it well.

About a fortnight later I was ordered to Melbourne to superintend formation of sapper companies there, and was appointed C.R.E. We expected to get away early in October, and had actually started embarking, when the scare of the *Emden* delayed us. Eventually we sailed from Melbourne on October 16th.

The transports from the Eastern Ports rendezvoused at Freemantle while the New Zealand transports and those from West Australia joined us in the vicinity. We then, with our naval escort, formed a fleet of close on fifty vessels, and our exit from Freemantle Harbour must have been an inspiriting sight. We proceeded in three columns, one mile between columns, with the *Orvieto*, the headquarters ship, leading the centre. Considering that none of these ships had ever been accustomed to keeping stations we maintained our formation very well. A novelty was the large number of horses in some of the ships. Many prophets shook their heads, and prophesied that the tropics would finish most of them, and certainly it was terribly hot on some of the lower horse decks. But we only lost five per cent. of our number, and some of the best equipped ships had no losses at all, though the animals were on board for from two to two-and-a-half months. We were favoured with fine weather once clear of the Bight.

The only excitement of the voyage was the finish of the *Emden* by the *Sydney*. I came on deck early that morning and was surprised to find the *Melbourne* athwart us evidently conversing. Shortly after the *Sydney* went off at speed, and various rumours were rife. The Japanese battleship now got restless, hoisted her ensign fore and aft wherever an ensign could be hoisted, and cleared for action; a most imposing sight she presented. (By this time we knew the *Emden* was the quarry!) A little later she dashed off, belching smoke, but before she got hull down we got the *Sydney's* signal "*Emden* beached and done for," and back she came. At Colombo two days

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later we found the *Sydney* looking a bit battered, and we took on board the Captain and one hundred other ranks taken from the *Emden* and these stayed with us till Egypt.

We arrived in Egypt early in December. The companies were very busy training at Mena, and I had to do C.R.E. of camp, which left me little time to look to the companies. I realized early what an advantage we had over the infantry by having a small nucleus of Regular Officers and N.C.O.'s of the Australian Permanent Engineers, who were invaluable. With the infantry it was, in those early days, sometimes a case of the blind leading the blind. The camp was overcrowded, and the water supply a continual source of worry, but the men worked hard, so hard, in fact, that they were for a while overworked.

We owe a deep debt to the Egyptian State Railways for all they did for us in the way of completing and repairing our equipment. They also made complete pontoon equipments for the three field companies, and generally acted as our Ordnance repair shops. By the end of March we were all eager to get away, and rumour said that we should soon move, though no one could say where. Eventually we heard that we were to make a landing somewhere. We entrained for Alexandria early in April, and found the harbour crammed with ships, after a slight delay, sailing for Mudros. Here we had a further wait to allow the transports to assemble. Our objective then became pretty well known. I formed one of a party of military officers who made a reconnaisance trip of the Gallipoli coast in the *Queen*. When on deck we were disguised in naval overcoats for fear our plans should leak out.

The preparations for the landing were certainly worked out with infinite care. I was warned as C.R.E. that the provision of a pier and the water supply would be my immediate problems. On the afternoon previous to the day fixed we stood out from Mudros, then crammed with a most heterogeneous collection of battleships, transports, cargo boats, etc., and stayed the night in a bay nearer the Turkish shore. The weather held calm and our leading brigade disembarked from the battleships and made the landing at dawn. It was fortunate that the navy landed them about a mile north of the spot selected (Gaba Tepe), which proved a hornets' nest and never passed into our hands.

It was a day of vivid contrasts. Not being detailed to land till 8 a.m., I had time for a bath, a luxurious breakfast, and a smoke on deck before I gathered together my worldly goods, added a bag of biscuits slung round my neck, and, much encumbered, clambered down a rope ladder to the deck of a destroyer, which took us to within a few hundred yards of the shore where we tumbled into cutters and stepped ashore dryshod. All this while promiscuous shelling was going on, but nothing very much. The *Goeben* threw over the first

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big one just as we left our transport. Considering the number of ships, and the good observation Abdul had, it was extraordinary how few hits were made. I only saw one, on the waist of a collier, but it did not put her out of action. Nearer the shore a tug was hit and very slowly sank, her smoke stack, alone visible above water, being for weeks a conspicuous warning to navigators

One field company had landed with the advanced brigade and was already at work cutting rough paths through the scrub, and searching for water. In this search we were more successful than we expected, and the local supply for the first few days was a material help. At this time, 9 a.m., the news was good from all quarters. In the course of the morning my eyes were gladdened by the sight of our barrel pier rafts slowly approaching the shore. Made up complete, they had been carried on a transport and were slung overboard and towed in. By noon they were in position as a pier for landing stores, and another rough pier was made of large stones from the beach, which was used during the afternoon for off-loading tins of water, and for the evacuation of wounded. By mid-day came news that our advance was checked, and as the afternoon wore on there was a feeling that things were not so bright as in the morning. As night fell this feeling increased, and by this time the beach was littered with wounded. Nevertheless by sheer hard work on the part of the A.A.M.C. these had all been evacuated before the next morning. That was an unhappy night. The rattle of musketry was continuous, rising and falling in intensity like the surge of the tide on a beach. However, stores were coming in well, and the New Zealand and Australian Divisions had finished disembarking during the afternoon.

The topography of our immediate hinterland had to be seen to be believed. The plateau immediately formed by the cliffs gave no access to the heights further in, being cut off from them by a deep gully. Our main objective, Sari Bar, was on our left front, but for the time being it was a question of holding what we had. It was most remarkable the next morning how everybody's spirits revived. The gloomy views of the previous evening vanished. The arrangements for landing stores and the further search for water supplies kept me busy. The sappers, in the meantime, were improving paths and roads, and digging an interior line of trenches, in addition to the hundred and one other odd jobs to which he is always heir. Already there were cries for barbed wire, timber of every description, tools, etc., etc., more than our small stocks could supply. My first visit to the front line was on the third or fourth morning. In those early days, the necessity of digging had not yet been fully appreciated by the infantry, and my chief impression of that trip was the enormous difference it made in the morale of the men whether they had got well dug in or not. Where they had fair trenches, they were happy and confident, where they had not, they were unhappy

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and apprehensive. I spent most of my time conjugating the verb "to dig," chiefly in the imperative mood. The advantage of clearly written notices was also borne in on me. It is disconcerting when you have spent some moments deciphering a pencil scrawl to find it reads "It is death to linger here," or "A sniper has this spot set;" but these notices only appeared later. Our left at this time consisted mainly of isolated posts, communication between them in daylight was impossible, and we were busy sapping from post to post to make a continuous line. Snipers held the high ground at the head of the main valley, our chief artery, and with them you played the game of "p'raps" as you travelled up and down it, till we had time to build traverses and cut communication trenches. Our front line had deep indentations; it was formed just where our infantry had been stopped on the first morning. This was gradually corrected by sapping. From this sprang our first attempts at mining, and fortunate it was for us that the soil stood without timbering, for the supply of timber would have been out of the question. Attempts to advance our line met with no success and heavy casualties, and a system of trench warfare, with the accompanying trench nuisances, bombs and grenades, gradually developed. The local water supply gave out after the first few days, and had to be brought over on barges and pumped into tanks on the beach, thence carried by man or mule to the consumer. Abdul's shrapnel had overshot the beach for the first day, but thenceforward there were no reasonable grounds for complaint as to the accuracy of his shooting, and the pumping parties had a trying time. Just three weeks after the landing I got a bit, and Gallipoli saw me no more till late in July.

On my return I found the feeling that we were securely "top dog," and that while we could not advance, we were secure from being driven off. By this time the sappers were chiefly employed on underground work, protecting our front line with a system of tunnels. We were lucky indeed to have such large numbers of skilled miners in the infantry, and from the early days we always had the mastery underground. Sent off in August to Egypt to form fresh field companies for the newly forming 2nd Australian Division, I returned in September with two companies formed from volunteers from the infantry, and what tools we could procure in Cairo. My work lay more and more in the tunnels under-ground by which we were trying to make local advances and provide shelters for the men. I remember taking over one set which had simply grown, and was like a rabbit warren. They were most unpopular, and progress through them was a series of gymnastic exercises. Work was concentrated on improvements to exits and entrances, and making the main gallery passable for men walking upright. The improved results in the forward work when resumed were surprising. We sank, against my wishes, one deep shaft which was to come out or fire a large mine some 1,200

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yards beyond our front. The men worked steadily and were good miners, but the climate and conditions were telling, and our progress rarely came up to our estimated rate, low as this had been put. I mention this to show that with any amount of good will, you cannot get anywhere near the same amount of work out of men under trying climatic conditions, as in ordinary life, and that estimates based on work done in civil life are most misleading. At this time we were firing a mine or two nearly every day. Abdul retorted in kind, but as his chiefly went up in no man's land, no great harm was done, indeed our casualties from his mines were surprisingly slight considering that in the "Lone Pine" and some other sectors, we were at very close grips, and had broken into some of his tunnels. By this time the beach and its surroundings were hardly recognizable to the early inhabitants. Traverses of provisions and fodder had completely altered its appearance, and saved many lives, while scrub and everything that could light a cook's fire had disappeared from the hills. By now the Suvla push had come and gone, and one had the feeling of rats in a cage. The after-effects of suffocation in a mine caused me to be evacuated early in November, I therefore missed that most extraordinarily brilliant piece of work, the evacuation in December.

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CORRESPONDENCE.

SITING OF TRENCHES.

To the Editor, R.E. JOURNAL.

SIR,

With reference to the article by " H.B. " on the " Siting of Trenches " which appeared in the June number of the *R.E. Journal.* I would like to make a few criticisms from a point of view which I venture to think has not yet received the consideration it deserves.

I refer to what was known during the war as " Field Survey Observation." The writer of the article mentions the necessity for obtaining " Artillery Observation " of the ground for at least 400 yards in front of the line of resistance but he says nothing about the equally important necessity for maintaining observation over the enemy's " battery " areas, possibly because it is thought that these can be adequately watched from aeroplanes and balloons.

It is unnecessary to comment on the value and importance of effective " Counter battery " work, but few people, I imagine, outside the comparatively small number of officers who have been concerned during the war with the location of enemy batteries and the direction of " Counter battery " fire, realize how strictly limited are the possibilities of aeroplane observation, or what can be done in the way of properly organized ground observation, for location of hostile guns.

My own experience during the war is that when our own line was favourably situated for this class of work, as for example in the Nieuport Sector in 1917 or the " Lys Salient " formed by the German advance to Merville in 1918, the number of hostile batteries located by ground observation, that is to say by intersection of the flashes of the guns from properly surveyed O.P.'s, was not less than six times the number located by our balloons and planes put together. The locations moreover being far more accurate, and generally also effected far more quickly.

In July and August, 1918, it was my duty to carry out a reconnaissance of the defensive lines which had been prepared by us in front of St. Omer with a view to selecting positions for this kind of observation, and it was perfectly evident from the nature of the positions selected that no attention whatever had been given, in siting the trenches, to this question ; with the result that if we had had to occupy this line we should have been virtually compelled to forego a form of observation from which we could have derived the greatest advantage.

I would, therefore, like to state briefly the attributes of a good position from the point of view of the " Flash Spotter " in the hope that any R.E. officer who may be called upon to select a position for a defensive

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line in the next war may give his requirements due weight and consideration.

The best sites for flash spotting O.P.'s are those which give a good all round view of the areas likely to be occupied by the enemy's guns, and their positions, with regard to our own front line, should be such that the enemy cannot reach them and disturb the observer with machine guns. That is to say the front line should be sited about 1,500 to 2,000 yards in front of them, not " several hundred " yards as laid down in para. 5 of the article referred to.

Gun flashes can be seen at great distances if the observer's position has sufficient command to make it difficult for the enemy to defilade the flash from him, and with the instruments used the distance from the flash, within limits, has little effect on the accuracy of the location provided the observer can make his observations in comparative security. I have known the position of a gun to be located by intersection of the flash with an error of only 60 yards at a distance of 14 miles.

M. N. MACLEOD, *Lieut.-Colonel, R.E.,*
Cmdg. 4th Field Survey Battalion, R.E.

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NOTICES OF MAGAZINES.

PETROLEUM.

THE information given below is drawn from a report on " The energy resources of the United States : a field for reconstruction " by Chester G. Gilbert and Joseph E. Pogue, published quite recently by the Smithsonian Institution of the United States National Museum.

The peculiar value of petroleum is due to the fact that it is the sole source of gasoline (petrol), the dominant motor fuel, provides kerosene, yields lubricating oil, is becoming an essential fuel in districts where coal is scarce and in oil-burning navies, and forms the basis of an oil by-products industry, a branch of chemical manufacture still in its infancy and capable of unlimited possibilities of development. Its peculiar property of being a liquid adds greatly to the facility with which it can be mined and transported. Petroleum, or crude petroleum as the raw or unrefined product is often termed, is an oily liquid varying considerably in appearance according to the locality from which it comes. It is an extremely complex mixture of organic compounds, chiefly hydro-carbons, but substances containing sulphur, oxygen, and nitrogen are also present in small amounts. If crude petroleum is exposed to the air, it gradually thickens until a solid residue is left. The first product given off is natural gas, then liquid components evaporate in the order of their lightness ; and the final residue is composed largely of either paraffin wax or asphalt. Though petroleums vary considerably in character, they fall chiefly into two classes, those with a *paraffin base* and those with an *asphaltic base*. The former are richer in gasoline, while the latter are useful commercially in the form of fuel.

Petroleum in commercial quantities is found only at a considerable depth, enclosed within the rocks of the earth's crust. It saturates certain areas of porous rocks, such as beds of sand or sandstone, tending to accumulate where such strata occur beneath denser, impervious layers. Occurring in this way under the pressure that obtains at these depths, carrying immense quantities of gas in solution, and almost invariably associated with water, it is capable of movement, and in general migrates upwards, and becomes impounded into " reservoirs " or " pools " under the domes found on the under side of the impervious strata supervening.

The geology of petroleum is therefore the geology of rock structure, and by skilful mapping of the earth's crust information may be obtained by which the development of petroleum fields may be changed from a gambling venture to an exact science. The chemical composition of the water encountered by the drill also gives some indication of the proximity of oil, and serves as a guide to successful development.

The process of winning the oil consists in puncturing the structural

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feature which holds it in restraint, so as to give free scope to a movement upwards to the surface. While petroleum is of very common occurrence in small quantities, areas underlain by commercial quantities are few. Two-thirds of the world's supply are at present found in the United States, while considerable quantities are found in Mexico and Russia, and smaller quantities chiefly in the Dutch East Indies, Roumania, India and Galicia. The Petroleum industry in America is in the hands of two classes of companies only, the producers, of which there are over 1,500 companies, and the companies which handle the oil—carrying out the operations of transportation, refining and distribution—of which there are only a few hundreds.

The oil is obtained from wells drilled to varying depths. The drilling is commonly done by means of a heavy string of tools suspended at the end of a cable and given a churning motion by a walking beam rocked by a steam engine. This method is known as the standard or percussion system of drilling. The steel tools, falling by their own weight, pulverize the solid rock and punch their way to the depth required. To prevent the caving in of the hole, but especially to avoid the inflow of water, the well is lined, or " cased " wholly, or in part, with iron piping, which is inserted in screw-joint sections at intervals during the drilling and forced down to positions needful of such protection. The well does not taper, but, if deep, changes to successively smaller bores at several points, resembling a great telescope.

Another method, known as the rotary system, is also in common use, being adapted to regions where the sides tend to cave badly. In this system the iron casing is tipped with a steel bit and rotated so as to bore its way downward like a great auger.

A successful well eventually penetrates the oil-bearing bed, and the petroleum may spurt forth under the influence of the natural gas held in solution under pressure. These wells are called " gushers " and some pour forth prodigious quantities of oil. Others flow with less violence, and many yield only to pumping, if notable quantities of natural gas are lacking. All wells soon reach a maximum production, after which they soon pass into a period of decline, and eventually become extinct. Wells during decadence may be stimulated by firing charges of nitro-glycerine at their bottoms, and experiments have also been tried in forcing compressed air into some exhausted wells in a group, with a view to driving residual oil into the neighbourhood of other wells from which it can be pumped.

As single wells soon become exhausted, sustained production requires the producing companies not only to draw oil from existing wells, but to persist in drilling an increasing number of new wells, and to select promising fresh sites for future operations.

The expression " wild-cat " operations is used for drilling wells where oil has not been proved to exist. Wild-cat companies are generally small ones which do not afford to spend much money in geological research, but the " wild-catter " has his uses, and gains good positive or negative evidence, for there is a great deal of chance in the industry and without some gambling a large proportion of the oil would never have been found.

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Turning now to the companies which handle the oil after it has been raised to the surface, the first operation carried out by them is *transportation*. This is almost entirely done by means of pipe lines, the principal systems of which, in America, are calculated to aggregate 28,995 miles. The pipes vary in diameter from 2 to 12 inches, but 6 to 10 inches represent the common sizes. The piping is made of iron plate and is ordinarily placed below the surface of the ground. At intervals of 15 to 30 miles, according to the viscosity of the oil, are pumping stations, where powerful pumps seize the spent oil and force it forward. In the case of heavy viscous oils, it becomes necessary to heat the product at each pumping station. Unlike a railroad, the pipe-lines, in general, follow a direct course, uphill and down. A coasting service of tank steamers also plays a part in the transportation of the raw material.

Crude petroleum is used as fuel and for roads, but most of the oil is manufactured into a series of products which have wider usefulness and higher value. This *refining* is an ingenious mechanical device whereby the raw material, through the agency of physics and chemistry is fitted to the needs of society. As these needs are ever increasing in size and diversity, refining practice is in continuous flux, adapting a constant substance to a shifting and widening demand.

At present petroleum yields, when completely refined, four main products—gasoline, kerosene, fuel oil and lubricating oil—and a large number of by-products, of which benzine, vaseline, paraffin, road-oil, asphalt and petroleum coke are well-known examples. Most of these products can be broken up into other subjects, numbering some hundreds of substances of commercial value, and leaving scope for the further discovery of many more.

While refinery practice is highly technical and varies according to the chemical nature of the oil and the local demand for products, we may ignore details and note that there are three main types of refineries. Firstly, the " skimming " or " topping " plant, in which the light oils are removed from the rest of the products, which are sold in the semi-crude condition for fuel purposes. Secondly, the " straight-run " plant, which produces all the four main products and some by-products, the process separating the crude oil into its natural components with the minimum of chemical change. The third type is of recent birth, employing the so-called " cracking " process, which yields the full set of products, but a greater percentage of gasoline than the crude oil gives upon ordinary distillation. This is accomplished at the expense of the heavier component oils, whose molecules are broken or " cracked " into lighter molecules, which constitute a corresponding amount of additional gasoline. All types of refineries employ the principle of distillation in their operations. The petroleum is heated in stills, and the products vaporize, pass off, and are condensed in fractions, representing roughly the materials in demand. These products are then purified by chemical treatment, or transformed by chemical means into a series of secondary products.

The requirements of *distribution* are considered in the siting of the refineries. Distribution is not carried out by means of pipes, but use is made of railways and canals for inland traffic and of tank steamers for

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service overseas. Storage tanks are provided at distributing centres, and supply tank wagons radiate to comply with local needs. The system is highly organized and the results are evident in the wide-spread use of all petroleum products, but especially of kerosene, which penetrates into the most out-of-the-way regions of the globe.

A few words about the natural gas may be of interest. The gas produced is of two types, according to whether it carries a conspicuous burden of gasoline vapour or not. The first type flows from an oil-productive stratum and is called " wet " or " casing-head " gas. The second is " dry " gas and comes from portions of porous rock formations practically free of oil.

About one-third of the natural gas produced in the United States is used for domestic purposes—lighting, cooking and heating—while the rest is burned in industrial plants under steam boilers, and especially in metallurgical operations, glass and pottery furnaces and cement kilns, where intense heat is required. The drilling of gas wells is not essentially different from that of oil wells ; but gas, unlike oil, cannot be stored in the field and hence is piped directly to centres of consumption. The gas emerges from new wells under high pressure, but as this declines rapidly, the gas field is equipped with compressors which serve to increase the speed and volume of the gas under distribution. In general the pressure of casing-head gas is much lower than that of dry gas.

The waste of natural gas in the past was very great, and it used to be looked upon and treated as a waste product, but now it is known to be necessary to the proper recovery of the oil, and in oil borings the gas-bearing beds encountered are sealed off by means of mud-laden fluid, and the gas is saved for the protection of the oil beds and for subsequent recovery of the natural gas. The gas flowing from the oil-productive stratum along with the oil, particularly in the gusher and youthful period of production, is the casing-head gas from which, since 1910, a growing production of gasoline has been won. New processes are also being developed for the production of gasoline from dry gas also.

PROFESSIONAL MEMOIRS, CORPS OF ENGINEERS, UNITED STATES ARMY AND ENGINEER DEPARTMENT AT LARGE.

March—April, 1919.

The Development of Anti-Aircraft Searchlights.—By Lieut.-Col. James B. Cress, Engineers, U.S. Army.—Prior to the date on which the United States entered the war various types of mobile searchlights for the purpose of battlefield illumination had been tested. These included a horse-drawn 36-in. set, and a 36-in. light on a Strauss extension tower, mounted on one F.W.D. truck, with a motor generator on a second truck. This latter type had also been supplied to the Russian Government. More recently a large order had been given for 24-in. searchlight sets, similar to those manufactured for the German Government. These

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were horse-drawn, and consisted of limber and carriage, the former carrying the motor, while the latter was fitted with an extension mast supporting the high intensity light.

In the autumn of 1917 information was received that field searchlights were no longer used on the battlefield, but that enemy bombing operations were becoming so extensive that some form of anti-aircraft searchlight defence was essential. After various improvizations had been adopted, the question of a suitable design was taken up seriously in America, and an experimental detachment was formed who drew upon the large manufacturers of electrical equipment, numerous scientific bodies, and noted scientists, for advice in improving the searchlight and its power unit. Meanwhile experiments were made in reducing the weight of the equipment, which resulted in a carriage made up of a steel frame supported on standard Ford axles and wheels, and the reduction of weight to 1,600 lbs. in the case of a 36-in. light, and to 1,800 lbs. for a 60-in. light.

In the spring of 1918, it was suggested to abandon the front glass, which was found to absorb about 25 per cent. of the light. This resulted in the first Dishpan searchlight, composed essentially of the mirror, the mirror support, and the mechanism. With its carriage, the latest 60-in. light of this type weighs about 900 lbs. and gives a more powerful and effective light than an enclosed searchlight, using the same mechanism, current and mirror. Compared with the 60-in. sea-coast searchlight in use before the war, it costs about one-fourth as much, weighs about one-eighth, and is more powerful.

Another important development was the adoption of a metal mirror. At the outbreak of war, only one firm in the United States manufactured glass mirrors, and their output was limited to approximately one mirror per week. It was also almost impossible to obtain optical glass. Before the war closed three firms could produce glass mirrors, but, more important still, a type of metal mirror had been developed which could be turned out in unlimited quantities, and at a cost of about one-third that of the glass mirror. The final design of the metal mirrors has yet to be determined, but it is certain that they can be effectively used in the place of glass mirrors, and that they have many advantages over them. They will not shatter when hit, they are cheaper and more easily procurable, and, more interesting still, they permit of a higher development of the searchlight than had been previously considered possible. Because the glass mirror absorbs about eight per cent. of all the incident light and because of the poor conductivity of glass, mirrors made from it become hot, and, in practice, have usually cracked when used with arcs carrying more than 200 amperes. The metal mirror, however, runs cold with these powerful arcs. This quality, when considered with the efficiency of the metal mirror, which the latest tests have shown to be from 95 to 99 per cent. of that of the best glass mirrors, is alone almost enough to warrant its adoption to replace the glass mirror.

The development in America of the manufacture of carbons for high intensity lights—that is, for lights which use an incandescent carbon

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gas as their illuminating source—has also been successful, the locally-made carbons are cheaper than those previously considered standard, and give three times as much light.

The development of mechanism has made it possible to use a much higher current density, which produces a more intense light, with either a longer range or a greater field. The medium intensity light—that one in which incandescent carbon forms the source of light—as well as the high intensity, have been carefully investigated, and both medium and high intensity lights taking as much as 500 amperes have given satisfactory tests. Whether the blue light produced by the high intensity arc, or the yellow light produced by the medium intensity arc, is better for picking up aeroplanes, will soon be carefully studied.

The article is illustrated with reproductions of photographs of various types of equipment. Other articles included in this number deal with:—(i.) Technical engineering details of the Hindenburg line in the sector of attack of the II. Army Corps; (ii.) a technical description of the British Light Railways in France; and (iii.) The Coblentz Pontoon Bridge.

REVUE MILITAIRE SUISSE.

No. 6.—June, 1919.

THE GERMAN AND FRENCH CAVALRIES IN THE GREAT WAR.

The article on the above subject by Colonel Poudret, begun in the number of the *Revue* for March last, is continued in the number under notice. Attention is called by Colonel Poudret to the fact that not only had the French cavalry to be reorganized and completely re-armed, whilst a fierce war was actually in progress, but its training had to be carried out on entirely new lines. The French Regulations of 1916, it is pointed out, contained a chapter on "Methods of Training," whilst in the Regulations of 1918 the subject was amplified and completed in matters of details. An extract is given from the latter Regulations wherein it is laid down that: "It is an imperative duty for every one to be continually increasing his own personal efficiency and that of his subordinates by training. For the Chief who "understands his business" does not call upon his men to exert themselves uselessly; he does not tire them out prematurely and in the battle does not risk their lives unnecessarily."

"The absence of knowledge is fatal. It makes a Chief irresolute and timorous, causing the men to lose their confidence in their leaders."

During the war the training of the large cavalry formations was periodically carried out with each formation complete in all details, *i.e.*, its staff, its artillery and its cyclists.

Even when cavalry units were taking their turn of duty in sectors of defence they were required to continue, as far as was possible, their training. Such training was based not only on the Regulations of 1918, but also on instructions contained in pamphlets and manuals issued

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both previously to and since the outbreak of war. During such training, suitable schemes were set, in which the Special Idea often represented a situation of a kind in which a large cavalry formation would have been called upon to play a rôle had such a situation come into existence during the campaign. In other cases *études de combat* were carried out during which complete sets of orders were issued to every unit exactly as would have been the case in an actual engagement.

Individual training was carried out in the platoon and *group training* in the demi-squadron, squadron, demi-regiment, regiment and brigade, whilst *mounted training* was carried out in connection with manœuvres. Such manœuvres involved the execution of some scheme representing operations in which, according to the Regulations, large cavalry formations and divisional cavalry would be called upon to play an important part. During such exercises movements in extended order were practised, with a view to illustrate a rapid advance of cavalry under artillery fire over rough ground.

The labour devoted to this training was not spent entirely in vain, although in view of the precipitancy with which the Germans accepted the Armistice terms, the cavalry was deprived of the opportunity of reaping the full advantage therefrom that it had counted upon. The part played by the cavalry during the critical days of the spring of 1918 is touched upon. As is well known now, the Germans spent the whole period from November, 1917, to March, 1918, in ceaselessly transporting troops from the Russian to the Western Front. No secret of war was so well kept as the German design to break through the Allied front during their last great offensive. Forty German divisions were collected on a front of 50 miles, between the Scarpe and the Oise, with the object of separating the British from their Allies and of thus opening the road to Paris.

The German "push" began on the 21st March, and with the first fierce onslaught the British 3rd and 5th Armies were driven from their first positions and in some cases from the second also. Lassigny, Roye and Noyon fell and a gap was created between the British and French Armies. The French G.H.Q. at once made use of the reserves, and amongst the first of the troops to be moved forward was the 1st French Cavalry Division (General de Rascas); it advanced on Noyon and heroically came into action against the Germans who out-numbered them in the proportion of 10 to 1. The 9th Cuirassiers were decimated in the obstinate fighting on the borders of the Bois de Frières.

The Germans occupied Noyon on the 25th March. The 1st French Cavalry Division then proceeded in haste to Roye to join General Robillot, who was at the time commanding the 2nd French Cavalry Corps, as well as the 22nd and 62nd Infantry Divisions—these troops were responsible for the defence of the Roye sector.—(*To be Continued*).

Machine Guns in Action.

The article on the above subject by Captain Bridel is concluded in the number of the *Revue* under notice: questions affecting the employment of machine-guns in the offensive and in the defensive battle are examined. The Commander-in-Chief of the Swiss Army, it is pointed

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out, issued an instruction in July, 1917, containing the following statement: "The preparation of troops for battle has one sole end in view, the preparation for the attack; the attack in a war of movements or the *combat de rencontre*, the counter-attack in the defensive battle and the assualt in trench warfare are but variants of the attack."

The question of the part that machine-guns should play in the offensive battle is discussed. The conclusion is arrived at that where the *terrain* and circumstances permit, machine-guns should come into action on the same line as the infantry or only slightly in rear of this line. The advantage of having machine-guns on the same line as the infantry is that the latter derive a certain measure of confidence by being so closely supported, and there is also the further gain that the positions of the machine-guns are under such circumstances, less easily located by the enemy. It is recommended that the machine-guns should come into action on that part of the front which affords most cover and where they can be pushed forward by short advances into positions whence they can bring oblique and flanking fire to bear on the enemy.

The Western Powers organized their machine-guns in "forward" groups and in "rearward" groups; the former term was applied to those machine-guns which came into action in conquered ground and were employed defensively, whilst the latter term was applied to the machine-guns employed in positions behind the fighting line to support infantry during and after an assault. The Germans had a similar organization, but used the terms "light machine-guns" and "heavy machine-guns" respectively for the two groups.

Towards the middle of 1918, each section of infantry in the German Army had two groups of light machine-guns allotted to it: these two groups were intended to afford each other mutual support. On being taken forward from the trenches these machine-guns were entrenched in "offensive nests": the duty was imposed upon them to co-operate closely with the infantry when it advanced, and to assist it by keeping down the fire of the enemy's infantry and machine-guns. As soon as the first wave of attack of their own infantry reached the enemy's position and occupied it, these machine-guns were pushed forward in order to help clear the enemy's trenches, and to cover the reorganization of their own assaulting columns.

The two important matters which commanders of machine-guns have continually to attend to in the attack are the making good of casualties in their gun teams, and the maintaining of a sufficient supply of ammunition.

The Great War has shown the very valuable rôle which machine-guns can play in the defensive battle. The Swiss Regulations lay down the rule that machine-guns shall be entrenched approximately at intervals of 30 paces, and that their positions shall be masked as completely as possible.

All the belligerents, it is pointed out, attached considerable importance to distributing their machine-guns in deep echelons; the reason being that the enemy's infantry and also his artillery barrage advanced in parallel lines, and in consequence, by the distribution in depth there was not the same risk incurred of losing all the machine-guns in a single

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assault as would have been the case had they been all placed in the front line. Further, it also became customary during the war to entrench machine-guns singly instead of in pairs, as had been the practice in peace exercises before the war

When employed on the defensive, machine-guns are organized in two categories also, namely, the " forward " group and the " rearward " group. The former groups act under the orders of their own commanders in direct support of the infantry, whilst the latter groups conform to the orders of the superior commander and are employed to put up a barrage and also to direct their fire on moving targets indicated to them.

As a rule, machine-guns should be placed in support trenches, as they are less liable to be taken by surprise there. It is recommended that these guns should be placed chequer-wise in a defensive position—the chequer should be of considerable depth. It is suggested that a suitable basis for calculating the number of guns for a sector of defence would be as follows :—" forward " group, an average of one machine-gun per 100 yards of front per line of defence ; "rearward " group, an average of one machine-gun per 30 yards of front per line of defence.

When an alarm is given the " rearward " groups should at once put up a barrage. If the enemy has already come within their limit of range, it is the duty of these groups to prevent reinforcements and ammunition coming forward. Machine-guns, it is recommended, should never attempt to fire on air-craft flying at an altitude greater than 3,000 feet—machine-guns require special mountings to enable them effectively to come into action against air-craft.

Notes have been issued in Switzerland giving detailed information concerning the factors which influence the fire of machine-guns against air-craft. It is recognized that ordinary range-finders cannot be satisfactorily used when flying air-craft constitute the target : attention is called to the *télémètre avec correcteur de hausse*, introduced into the French Army to overcome difficulties of ranging in such cases. Reference is also made in the original article to the tables prepared for the use of the British Army, and intended to serve a similar purpose.

The lesson that Captain Bridel wishes inculcated above all others is that soldiers should be taught not merely to fight, but to fight with intelligence, with all their strength and to the last ounce of it.

The Necessity for Specialization in the Army.

Lieutenant James Quinclet, the author of the original article, calls attention to an address recently given at the Military Club of Geneva by Colonel Vuilleumier, the G.S.O.,*I.* of the Swiss 1st Division : the subject of the address related to the means and methods to be employed to bring about a democratisation of the Swiss Army.

Lieutenant Quinclet tells us that the experiences of many officers during the period of the mobilization of the Swiss Army, 1914—1918, were such as to discourage, to disillusion and even to disgust them.

Colonel Vuilleumier covered, it would seem, a great deal of ground in his address ; Lieutenant Quinclet, however, deals with one only of the matters touched upon, namely, " Specialization according to

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functions." The fallacy that those in a higher grade of the army must always be superior in every respect, morally and materially, and in all things, to those inferior in rank to them, has, it is pointed out, widespread currency in Switzerland. For example, according to the accepted theory, the company commander should be the " best shot," the best scout, the best horseman, the best instructor etc., in his company. The prevalence of this idea, it is said has proved extremely prejudicial in matters affecting the training of the units of the Swiss Army; since those occupying subordinate positions, who have been imbued to some extent with the doctrine which placed the chief on a pedestal of superiority, knowing that their work might be corrected or subjected to criticism—unjustly according to their views—have failed to take a proper interest in their work. The result of this has been to create in the ranks that mischievous feeling which sometimes is referred to as being " fed up."

The proper cure for this state of affairs, it is urged, is a " specialization according to functions " : that is to say, the separation of the function of " command " from that of " instruction." In accordance with this scheme " command " would be vested in a superior whose responsibility would consist in ordering, disposing, and sanctioning; on the other hand, such superior would not himself impart instruction—except where he was peculiarly qualified to do so—but this duty would be carried out under his directions by a subordinate selected by him on account of such subordinate's special fitness and qualifications to undertake the particular task assigned to him. For instance, the duty of explaining the details of a machine-gun would be assigned to a subaltern perfectly familiar with the mechanism, and in the event of no officer being present possessing sufficient knowledge of the subject, a qualified N.C.O. would be detailed for the purpose. Similarly, equitation would be taught either by an officer who had the qualifications of a riding-master, or by a N.C.O. so qualified, etc., etc.

" Specialization according to functions " arranged on an intelligent basis and carefully controlled by the C.O. would, it is suggested, considerably stimulate the subordinate ranks. To meet the contingency of casualties in the ranks of the instructors it would alone be necessary, it is pointed out, to provide a suitable number of under-studies for each branch of instruction requiring attention.

NOTES AND NEWS.

Switzerland.—The Federal Council has announced its intention to promote a popular discussion on the question whether Switzerland should join the League of Nations as one of its members or not. In this connection attention is called in the Notes to M. Paul Crokaert's work *L'immortelle mêlée* (Perrin et Cie, Paris), dealing with the military situation in Belgium in 1914. The danger of a " guaranteed " neutrality and those of a " perpetual " neutrality are also briefly discussed.

The appointment of Colonel Sondregger to the position of Chief of the Swiss General Staff seems to have given general satisfaction in military circles.

The death of Colonel George Favey, which took place at Lausanne,

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on May 26th last, is announced ; he it was who first organized the Lines of Communication services in Switzerland.

United States of America.—A special correspondent contributes notes dealing with the demobilization of the American Army ; the future of the National Guard ; the proposal to hold a review in New York in connection with peace celebrations—the proposal is not viewed with favour on account of the probable expense, viz., £180,000 ; questions relating to uniform and the distinctive badges to be worn thereon ; the mutiny of a company of an American line regiment near Archangel on March 30th last ; and the proposed reorganization of the American Army to meet the new peace conditions.

Information.

Switzerland.—A short note is published under the heading " Military Education " ; therein the necessity for the adoption of every means to foster and secure good feeling between all ranks of the army is urged.

The Herzog Trust.—The objects of this trust, founded particularly for the benefit of artillery officers, are set out in the original note.

Bibliography.

A notice on General Berthaut's work *L' " Erreur " de* 1914 (published by G. van Oest et Cie, Paris and Brussels, at 4 fr. 40 c.) appears under the above heading.

Information relating to other works of military interest published recently on the Continent is also contained in this part of the number of the *Revue* under notice.

W. A. J. O'Meara.

RIVISTA DI ARTIGLIÉRIA E GENIO.

February, 1919.

The Bombardments of Paris and of Dunkirk.

The first bombardment of Paris by German aeroplanes of the Taube type took place on the 30th August, 1914, five bombs being discharged, and was renewed with a few bombs on successive days up to the 1st September. Other bombardments took place on the 27th September, 8th, 11th and 12th October of the same year, and the 11th and 22nd of May, 1915. These were the only bombardments by aeroplanes of the Taube type, which discharged, altogether, 58 bombs in 10 visits, killing 11 persons and wounding 50. The projectiles were of four types:—cylindrical-conical incendiary bombs weighing 4-5 kg.; spherical explosive bombs of the same weight ; pear-shaped with shrapnel weighing 3 kg. containing 150—175 bullets of 12 g. ; and of the same form but larger of 15 kg. and 30 kg. There were no fires. The first attack by dirigibles of the Zeppelin type on Paris and its suburbs took place on the 21st

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March, 1915, six bombs being discharged. These caused slight damage, viz., two or three small fires which were easily overcome, and wounded a dozen persons. The second and last visit of these dirigibles occurred on the 29th January, 1916; 17 bombs fell which killed 20 persons and wounded 28. The projectiles were more powerful than those dropped from the Taubes, and were exclusively of two types:—spherical explosive bombs weighing 60 to 130 kg. charged with powerful explosive (tolite or trinitro-anisol); and incendiary bombs of 8 to 10 kg.; these last had very little effect. Large fires were only caused by explosive bombs under favourable conditions.

For about two years Paris was not bombarded, but on the 31st January, 1918, there commenced attacks by powerful bombing aeroplanes of the Gotha and other types. The first attack caused the greatest damage owing to the discharge of 269 projectiles on the city and suburbs. There were many victims.

The projectiles discharged from these aeroplanes were described in the *Rivista** ; a few data are given below :—

	Number of bombs.	Number that failed to explode.
Spherical bombs of 300 kg. ...	5	3
,, ,, 100 ,, ...	57	19
,, ,, 50 ,, ...	232	26
,, ,, 10 ,, ...	279	25
Incendiary ,, 10 ,, ...	7	4
,, ,, 5 ,, ...	64	23
Not identified	20	—

On the 28th March, 1918, the bombardment of Paris by guns of long range commenced, 18 projectiles falling in the city that day; and the bombardment continued on successive days with few intervals up to the 27th April. After a month of tranquility it recommenced on the 27th May and continued with very irregular intervals up to the 10th June, and again from the 15th July to the 9th August, which was the last day of action of these guns. Altogether 303 shots were fired, resulting in 256 persons being killed and 620 wounded; the material damage was relatively less serious than that caused by the aerial bombs. It is confirmed that the calibre was 21 cm. and that all the projectiles burst without exception and that they were provided with two fuses. Experts have absolutely excluded the hypothesis that the internal charge was formed of two separate liquids, which united during the flight so as to cause an extra-powerful explosion. It is interesting to compare the effects of the two kinds of bombardment; the aeroplanes and the dirigibles dropped 303 shells, causing the death of 256 people and wounding 620. The casualties almost exactly balance, but the author states that the moral effect of the fire from the gun was much greater, because the projectiles arrived at all hours without it being possible to give the alarm or to take shelter in any way. The material losses caused by the guns were far greater than those caused by the aerial bombs.

* *Rivista*, 1918. Vol. iii., p. 80.

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The bombardments of Dunkirk at intervals between the 28th October, 1914 and the 11th November, 1918, are shown in the following list :—

Actions of	Bombardments.	Projectiles.	Killed.	Wounded.
Aeroplanes ...	177	5092	424	888
Dirigibles ...	1	11	3	9
Guns, land	32	411	114	185
„ naval	4	2000	7	32

The shells of 380 mm. which fell on Dunkirk were fired from a gun at Lemegembroom at 38 km. distance and were more effective than those of 210 mm. with which Paris was bombarded.

New Determinations of the Velocity of Sound.

In the *Comptes Rendus des Séances de l'Academie des Sciences* is produced a report by Ernesto Esclangon on a new determination of the velocity of sound—which is believed to be verified by several trials made in France during the course of the war—and on various problems for the determination of distance, and identification of the enemy's artillery positions, etc.

An exact knowledge as far as possible of the velocity of sound is of special importance in its application to the identification of artillery positions by means of sound. The precise determination of the velocity presents difficulties essentially derived from the imperfect knowledge of wind phenomena, since the influence of temperature is less and is easier to determine exactly. The influence of the wind is always badly determined owing to its continuous variation. The intensity of the wind is manifested in squalls and under-currents. Moreover, the measurements of the force of the wind depend upon the instruments used :— an anemometer, by the medium velocity of the fluid molecules that surround it a sound-balloon, on the other hand, by the medium velocity of molecules following its movement. In the propagation of sound there occurs a special integration, corresponding to the medium velocity of the several molecules met with successively by the sound wave, similar to the integration presented by the action of the wind on projectiles. If the wind is regular and constant these data would be identical ; but they vary owing to squalls ; and with very strong wind, the differences attain a value of several metres. When experiments in the velocity of sound are made at short distances, (some hundreds of metres for instance), all measurements correspond with the wind according to the phases and importance of the squalls, elements difficult of ascertaining. Further, in the immediate vicinity of the ground, the velocity of the wind produces a variation of barometric pressure, very rapid, irregular, and indeterminable, which provokes refractions and deviations of the sonorous rays. At great distances, (15, 20, 25 km. for example) the sonorous rays may be raised in the strata of the air by continuous refraction to a height the physical state of which is unknown. In calm weather it is observed that near the ground there happen other small irregular movements of the air, besides local variations of temperature, which cause great variations in the results, as has been

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repeatedly shewn by experiments in the camp of Gâvre. The measurements obtained from the sound of cannon shots give systematically numbers lower than those obtained by other methods. During the year 1917 to 1918 the author undertook at Gâvre the determination of the velocity of sound, working in the open under all conditions of weather, with strong winds, and a variable temperature, and with cannon of all calibres. The sound waves were collected in electric-acoustic receivers placed one at 1,400 m. from the battery and another at 1,400 m. beyond on the same alignment; the position of the two stations was fixed with the greatest exactness, the time was measured with an approximation of about $\frac{1}{500}$ of a second, and the wind pressure was determined by means of sound balloons. The observations made from June, 1917, to March, 1918, were taken from a series of experiments of 30 cannon shots each and were divided in two groups, the first with strong and irregular winds, with velocity up to 18 m., the other, with wind apparently regular, with velocity to 10 m. The results of the first group showed very sensitive differences up to 3 m., with an average of 1 m. These differences are indications of systematic errors due to the influence of the wind. With regard to the second group the average difference obtained in 100 observations for the sound velocity—corrected for the influence of wind, temperature, and humidity—was 2 m.

In conclusion the author obtains for the sound velocity, as deduced from the second group of the series, with 15 deg. of temperature and dry air, the value of 339·9 m. It may be noted that the velocity of sound according to the observations of Regnault made exclusively in calm air was shown to be 339·7 m. In the experiments made by Esclangon, (the calibres of the guns being from 14 cm. to 52 cm.), the velocity of sound does not appear to have been affected at a distance of 1,400 m. Finally the experiments seem to show that the velocity of sound is greater when the wind blows in a direction from which the sound is propagated but not in a contrary case. The difference, very slight with moderate winds, increases rapidly in the case of strong winds, this phenomenon being attributed to the oscillatory form of the wind (squalls).

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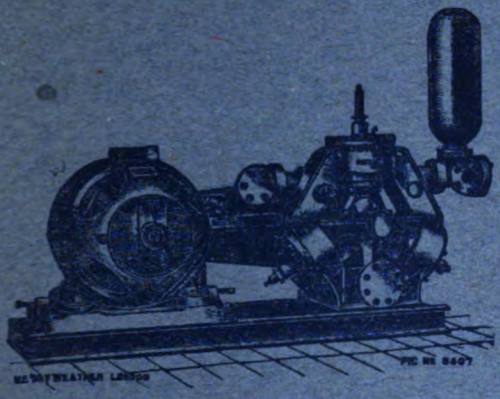

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BY

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THE ROYAL ENGINEERS JOURNAL.

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OFFICERS OF THE SPECIAL RESERVE, TERRITORIAL FORCE, AND THE TEMPORARY LIST, ROYAL ENGINEERS AND MEMBERSHIP OF THE CORPS ASSOCIATIONS AND CLUBS.

PROCEEDINGS of Meeting of the R.E. Corps Committee held in Room 230, War Office, July 21st, 1919 (in accordance with the resolution agreed to at the Annual Corps Meeting on 14th June, 1919.)

The following were present:—Major-Generals Sir P. G. Twining, (D.F.W.), *S. H. Powell, (C.E., Forces in Great Britain), *L. Jones, (C.E., Eastern Command); Brig.-Generals T. A. H. Bigge, (A.A.G., R.E.), *A. L. Schreiber, (C.S.M.E.), *G. S. Cartwright, (C.E., Aldershot), A. W. Roper, (I.R.E.), *G. Walker, (C.E., London); Major L. Chenevix-Trench, (Hon. Sec., R.E. Corp Committee).

* Specially attended with power to vote in accordance with resolution dated 3rd July, 1919.

AGENDA.—To discuss Major.-General Sir P. G. Twining's proposal:—

That in the opinion of this Committee it is not only desirable but is necessary that all possible steps be taken towards preserving the feeling of friendship and *cameraderie* which existed during the war between the Regular Corps of R.E. and the Special Reserve, Territorial, and Temporary Officers and Men, and that as a means to this end the R.E. Institute, and as far as possible other Corps Institutions, should be thrown open to these officers, and that steps be taken to bring this as far as possible to the notice of all such officers.

ACTA.—The opinions of the Presidents of the several R.E. Corps Institutions were read, and following conclusions reached:—

R.E. Widows' Society, R.E. Band Fund.—The deed of settlement in the one case and Army Orders in the other preclude the possibility of an extended Membership.

R.E. Institute.—Already accepts *all* R.E. Officers (including S.R., T.F., and T.C.).

R.E. Charitable Fund.—Already accepts *all* R.E. including S.R., T.F., and New Armies.

R.E. Games Fund.—Terms of admission to be considered by Games Committee.

R.E. Entertainment Fund, R.E. Dinner Club, R.E. Luncheon Club.—Officers of the T.F. and S.R. and Temporary Officers will be welcomed at the Annual Dinner and the Annual Evening Entertainment, and the Luncheon Club tent will be open to them.

R.E. Old Comrades' Association.—Already open to *all* Members of Corps of R.E. including S.R., T.F., and New Armies.

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Authors alone are responsible for the statements made and the opinions expressed in their papers.

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MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded annually by the Institute Council in the manner they consider best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. For the present the prize shall be confined to officers on the active list below the rank of Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie coat-of-arms in gilt on the cover and the Montgomerie book-plate with inscription inside. (*b*) The remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

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WATER SUPPLY DURING THE OPERATIONS AGAINST BEERSHEBA AND GAZA, NOVEMBER, 1917.

THE army which crossed the Sinai Desert into Palestine and then deploying on a broad front, enveloped the Turkish position extending from Beersheba to Gaza, demanded much of its engineers. During its deliberate advance it was followed by a broad gauge railway and a piped supply of filtered water from Kantara, on the Suez Canal, into the field of battle near Beersheba, a distance of 147 miles.

It would be an exaggeration to say that there is no water in the Sinai Peninsula, which separates Egypt from Palestine, but the supplies are so scanty and bad that the desert has always been a very formidable obstacle to the passage of troops. The only practicable route across this desert runs along its northern edge where scanty supplies of water are found in small wells on the caravan route or by digging new wells in the sand dunes, but, nearly all water in these wells is brackish and unpalatable and as a supply it is quite inadequate for a large force followed by an army of labourers constructing a railway. It was therefore necessary to provide the army with water from some source outside Sinai.

The water supply system, as originally planned, was only intended to supply 500,000 gallons a day for a force of one Mounted and two Infantry Divisions detailed to recapture the Egyptian town of El Arish, which was in the hands of the Turks, but, as it was extended beyond there and proved to be an important factor in subsequent operations it must be briefly described.

On the west bank of the Suez Canal, at its northern end, runs the Port Said branch of the Sweet Water Canal which carries the water of the Nile to that town. In the autumn of 1916, plant to filter 600,000 gallons of water per day was installed on the Sweet Water Canal at Kantara and the purified water was pumped through syphons under the Suez Canal into masonry reservoirs on the east bank. From Kantara East a water supply main of 12 in., 10 in., and 8 in. steel screw-jointed pipes was laid into El Arish, in four sections, each about 24 miles long. Duplicate engines and pumps drove the water from the reservoir at Kantara to a reservoir at the end of the first section and thence it was again pumped forward through the next section of pipe and so on forward, section by section, until it reached El Arish.

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To explain the work done on water supply it is necessary to describe briefly the system adopted for the distribution of water by rail and camel convoys and the clearest way to do this is to start from the beginning. Before the pipe-line from Kantara was laid and supplying water the Army had started on the march forward covering the railway construction parties and water had to be carried forward in trains of water trucks. These water trains were filled at a special siding, where 20 or more trucks could be dealt with simultaneously, and on arival at railhead, were emptied into a long row of canvas reservoirs laid beside the rails. Here, small camel tanks, called fantasses or fanatis, were filled up and these were carried forward by camel convoys for distribution to the troops beyond railhead. When the first section of pipe-line was completed a new water siding was provided and the railway was relieved of carrying water for the first stage and so on until water was finally pumped to railhead.

Once El Arish had been reached the army passed into a country where, within certain limits, the troops could be supplied with water from local resources. The railway engineers, however, rejected local water as unfit for use in its locomotives on account of its salinity and hardness; the railway, therefore, became the principal consumer of the piped supply; it was, however, also used by the troops to a considerable extent to supplement local supplies and in the final operations was a very valuable asset.

The army continued its advance from El Arish to Khan Yunis on a narrow front, along the caravan route, near the coast where the only water which can be found in the district is from wells in the sand dune area and in the villages of El Burj, Sheikh Zowaid, Rafa and Khan Yunis. At Khan Yunis two good wells about 100 ft. deep and at Beni Sela, an adjoining village on a higher site, a well 210 ft. deep were found. These three wells, when provided with pumps and engines, eventually supplied 130,000 gallons a day.

From Khan Yunis forward it became possible to extend on to a wider front, as water can be got in some parts of the bed of the Wadi Ghuzze and in its tributary valleys, from springs or in pools or by sinking shallow wells, while further to the right lay Beersheba whose wells have been famous since the days Abraham watered his flocks there. On the left front lay the village of Deir El Belah, with several good wells 20 to 30 ft. deep, the Wadi Ghuzze, and, further forward, the town of Gaza with abundant supplies of water from deep wells. The Turks abandoned to us Deir el Belah and Shellal, where the best supplies of water in the Wadi Ghuzze are found, but held on to Gaza and Beersheba.

For a time the army advanced no further but utilized the next few months in preparations and during this period much useful

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work was done in the development of local supplies and in laying pipe lines forward and to the right flank to enable troops to be concentrated where required.

The railway was extended to Rafa and thence to Gamli, and Shellal on the right and to Deir el Belah on the left. The water from Kantara followed the railway to Rafa, in 6-in. and twin 4-in. pipes, and to Shellal, supplying the requirements of G.H.Q. and El Fukhari on the way. A pipe line was also laid from the wells at Khan Yunis, *via* Abasan el Kebir and Abu Sitta, to Abu Bakra and this was cross-connected from Abu Sitta to Abu Khatli so that water could be distributed either from Rafa or Khan Yunis to any point.

At Shellal, springs yielding about 14,000 gallons per hour of somewhat saline water, had been cleaned out, covered in, and the water was led through pipes to a water distributing area. A natural rock basin had been improved by a masonry dam and provided storage for some 500,000 gallons of water. A pipe line had been laid forward from Shellal to Imara, and three sets of 25 h.p. engines and centrifugal pumps were installed for local distribution and to pump waste forward if required. The capacity of each of these pumping sets was 4,800 gallons per hour against a 200-ft. head, and the pumps were arranged so that any two sets could work " in series " to pump against a 400-ft. head, keeping one set spare in reserve. At Abu Bakra several miles of piping were held ready to extend the pipe line beyond the Wadi Ghuzze if required. At Mendur and at Dorset House deep bore wells had been sunk and provided with pumping engines. The Deir el Belah wells were connected up and, from these, water was pumped into the trenches S. of Gaza, while further to the left there was another smaller piped supply from the Red House wells. Along the Wadi Ghuzze and in the sand dunes near the coast wherever water could be got, and was required, wells had been dug.

Between March and October, 1917, the force in this area gradually grew to three mounted divisions, a brigade of the Imperial Camel Corps, seven infantry divisions, and a composite brigade of Allied and Indian Imperial Service Troops. General Headquarters moved into the area in August 1917, and preparations were made for an enveloping attack on the Turkish position at Beersheba, combined with a frontal attack on Gaza.

In *Plate* I. an attempt has been made to indicate the arrangement of the water supply up to and during the operations which commenced on October 22nd.

The supply of water which could be brought into the area by rail and delivered at Shellal or Gamli was some 100,000 gallons. The El Arish-Rafa pipe-line, after meeting railway requirements at Rasum, could supply some 156,000 gallons per day to Rafa, whence

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60,000 gallons per day could be delivered through Fukhari and Sheikh Nuran to Shellal or Abu Sitta. The Khan Yunis well and pumping station could supply some 100,000 gallons per day to Abu Sitta and thence by the cross line to Sheikh Nuran and Shellal, or direct to Abu Bakra. These transferable supplies from the rear, amounting to 260,000 gallons were controlled by General Headquarters during the course of the operations, and deliveries at the various watering points were regulated according to the daily movements of the troops.

The development of water supplies east of Esani was allotted to the Desert Mounted Corps, but could not be commenced until the date fixed for the first movement of troops into the area (Oct. 22nd). Preparations had to be made at once to collect suitable engines, pumps, and plant to restore and develop water supplies in an area which had not yet been occupied.

The development of water supplies in the Gamli-Shellal-Hiseia area, and east, including the improvements and restoration of the water supplies to Beersheba, when captured, was allotted to the 20th Corps, but no work east of the Wadi Ghuzze was to be taken in hand until October 22nd. The arrangements for the distribution of water in the Gamli-Shellal-Hiseia area, from which three mounted and four infantry divisions, accompanied by large convoys of camels for carrying water, were to start for the attack on the Turkish position, were of first importance. There is a considerable amount of water in springs and in pools in the bed of the Wadi Ghuzze within the limits indicated, but to make it available for rapid distribution involved a great deal of preparatory organization and work. At intervals along the valley a total of over 3,000 running feet of masonry and wood troughs were provided for watering horses and camels. In addition to the main road crossings, for use by transport, and roads for use of the troops moving out from the concentration area, special tracks across the Wadi had been arranged for animals going to and returning from water and others again for camel convoys carrying fanatis to and from the fantasse filling areas. All these roads were placarded with notice boards showing what formations had to use them, and where they led to.

At Shellal, a fantasse filling area, in which 2,000 fanatis could be filled and loaded on camels every hour, was organized, and the piping for the line to be laid forward, canvas tanks, watering troughs, and everything which was likely to be required for water distribution forward, were also collected here. At both Gamli and Hiseia pumping engines were erected to fill high level storage tanks, supplying water by gravity to fantasse filling areas, capable of filling 250 fanatis per hour.

The engines, pumps and plant for work in Beersheba had to be

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collected, loaded on tractor trains and held ready to push forward without delay when the town had been captured.

The maintenance and enlargement of the water supply in the area Mendur to Sheikh Ajlin, on the sea, and back to Deir el Belah, was allotted to the 21st Corps.

Until October 22nd no troops or animals watered east of the Wadi Ghuzze. After this date troops began to move eastward to take up their position for the attack on Beersheba. The following is a brief summary of the work done between October 22nd and November 1st:—

DESERT MOUNTED CORPS.—*Abu Ghalyun* was occupied at dawn on the 22nd October, and work on water development started at once. An old well was cleaned out, but failed to produce a satisfactory supply. Work on a second well was started but was abandoned. Meanwhile an Officer of the Australian Engineers "divined" water in the Wadi bed not far away. Two wells, sunk at the places indicated by him reached an abundant supply of water at 13 ft. depth.

Malaga was occupied the same day and here trenches dug in the Wadi bed provided a good supply.

Khalassa was occupied by the Camel Brigade on the night of the 22nd-23rd and working parties started at dawn of the 23rd to restore two wells which had been effectively blown in by the enemy. These parties, relieved every two hours, worked continuously until finally the wells had been cleaned out to a depth of 42 ft. and 36 ft. respectively. Pumps and engines with a capacity of 4,500 gallons per hour were installed and water sufficient for a division of mounted troops was stored.

Asluj was occupied on the night of the 25th-26th October, and work started at once on the restoration of wells which the enemy had thoroughly destroyed. After a great deal of heavy work, including the installation of machinery, Asluj on the 30th was in a position to water a mounted division, Corps Headquarters, and a considerable concentration of friendly Arabs.

20TH CORPS.—*Esani* was occupied by one mounted brigade and one infantry brigade on the night of the 22nd-23rd October. A party of 1,000 men of the Egyptian Labour Corps accompanied this force for work under the R.E., and work began on the morning of the 23rd. The source of water supply was springs and pools in the Wadi bed. Two portable power-driven pumping sets with a combined capacity of 8,000 gallons per hour, canvas storage tanks with a capacity of 150,000 gallons, and water distribution gear, were installed. 200 wood horse troughs filled by lift and force pumps were also provided in the Wadi bed. Work was completed within three days when a yield of 100,000 gallons per day had been attained.

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Imara.—On the 25th October storage capacity for 80,000 gallons was erected at Imara and the water was pumped forward to Imara from Shellal.

Karm.—Work on the pipe line from Imara to Karm was started on the 23rd. On this day five kilos. of pipe were laid out and screwed up in ten sections. On the 24th these ten sections were connected through, the pipe was tested and washed out, and storage tanks and distribution arrangements were completed at Karm. During the night of the 24th-25th the water was being pumped from Shellal through Imara to Karm and was available on the morning of the 25th for the use of the troops. Later, additional storage and second water distribution areas were provided at Karm for water brought by the rail from El Arish, and when the railway extension had been completed 80,000 gallons per day were delivered for some days.

Khasif.—At Khasif the cisterns were cleaned out and filled with 60,000 gallons of water, carried there by two camel convoys of 1,000 camels each on the 29th and 30th October. This provided an additional advanced reserve of water.

The water problem at Beersheba, after its capture, was not confined to the immediate provision of water sufficient for the minimum daily needs of the Cavalry Corps and two Infantry Divisions, in itself a large order, but it was necessary, with as little delay as possible, to make such preparations as would allow the second phase of the operations to begin. This could only happen when it was possible for the force to march out with a day's ration of water in hand for troops, and every animal to drink its fill before starting. The water question ahead of Beersheba was, at best, a doubtful one, and it was essential that when the advance from Beersheba began, the force employed should be in a position to face a long waterless period.

The Turks only destroyed a few of the wells before leaving, though all the principal wells had been prepared for demolition. This neglect, while most fortunate for us, was not creditable to the Turkish Engineers, for, however sudden the attack, it was only the work of a moment to light the fuses which were ready in position. Of the 17 wells in Beersheba, only two were thoroughly demolished, and two partly damaged. In three wells the pumps were in a workable condition though the engines had been put out of action. In three other wells, saqqias * were found in at least a workable condition, and though two of these saqqias were discarded as unprofitable and replaced by pumps and engines, the third was put in good working order in a few hours and was able to cope with the full yield of the

*A saqqia is a wheel fitted with buckets for raising water. It is worked as a rule by an animal pacing round in a circle on the principle of the old-fashioned mill.

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well. In addition the Turks had left intact two reservoirs containing some 90,000 gallons, a very useful legacy.

It was at once clear that the source of water in Beersheba was a large one and likely to provide nearly the whole need of that part of the force which was temporarily based on the town—a force requiring in all about 400,000 gallons per day. It was not to be expected that this volume of water would be available at once but horses can subsist without water for 48 hours, and men can do with less than a gallon per day if the weather is at all favourable as one might hope it would be in the beginning of November.

However, the three or four days after the capture of Beersheba were among the hottest of the year—a strong "khamseen" wind blew without intermission, and the whole of the district was enveloped in fine dust.

Of the plant carried by the tractor train five engines and three pumps were erected and parts of the sixth engine were used to replace similar parts in a duplicate engine left by the Turks. The three pumps left by the Turks were put in good working order. Four pumping sets brought in from Asluj were erected, one saqqia was put in order and used continuously and from two wells water was raised by bucket and rope. Several of the wells were concealed in houses and gardens; two were not found until the third day and one on the fourth day.

On the third day, in the afternoon, the water situation was most acute. Every available gallon of water stored during the previous night having been consumed. The output was just equal to the demand, and it was expected that watering animals for the day would be finished by midnight. At 1600 a Mounted Brigade of some 2,000 men and horses, with 48 hours thirst, arrived unexpectedly. A new well, with saqqia, had fortunately been found about noon n this day, the saqqia was being repaired and troughs were being erected, but there was no means of knowing what the yield of the well would be. This well was at work by 1700 and proved a good one, yielding about 1,500 gallons per hour, just enough to provide water by midnight for the Mounted Brigade.

During the first two days some water had been found in shallow pools and in pits dug in the wadi bed to the west of the town. This supply, however, was nothing more than surface water left from a storm which had occurred about a week before, and it was soon exhausted. By the morning of the fourth day the water development had reached its maximum, the total output was about 390,000 gallons per day, and after this there was no further great anxiety.

As an extreme measure an attempt was made to cut down the ration of water to horses by imposing a time-limit for each batch of horses as it came to the troughs. Such rationing might be

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effective where the control of the watering area was very perfect, and where animals had not been without water for an undue time. In the exceptional circumstances at Beersheba, the famished horses got out of control and rushed the troughs as soon as they got near them, and then while some drank greedily, it was a difficult matter to get others to drink. There is no difficulty in limiting the ration of water for camels as the camel habitually drinks in two "bouts" with an interval of about 10 minutes. Every line of troughing was provided with a stout guard rail. This was well worth the extra time and labour, as it prevented animals from breaking down the troughing in their eagerness to drink.

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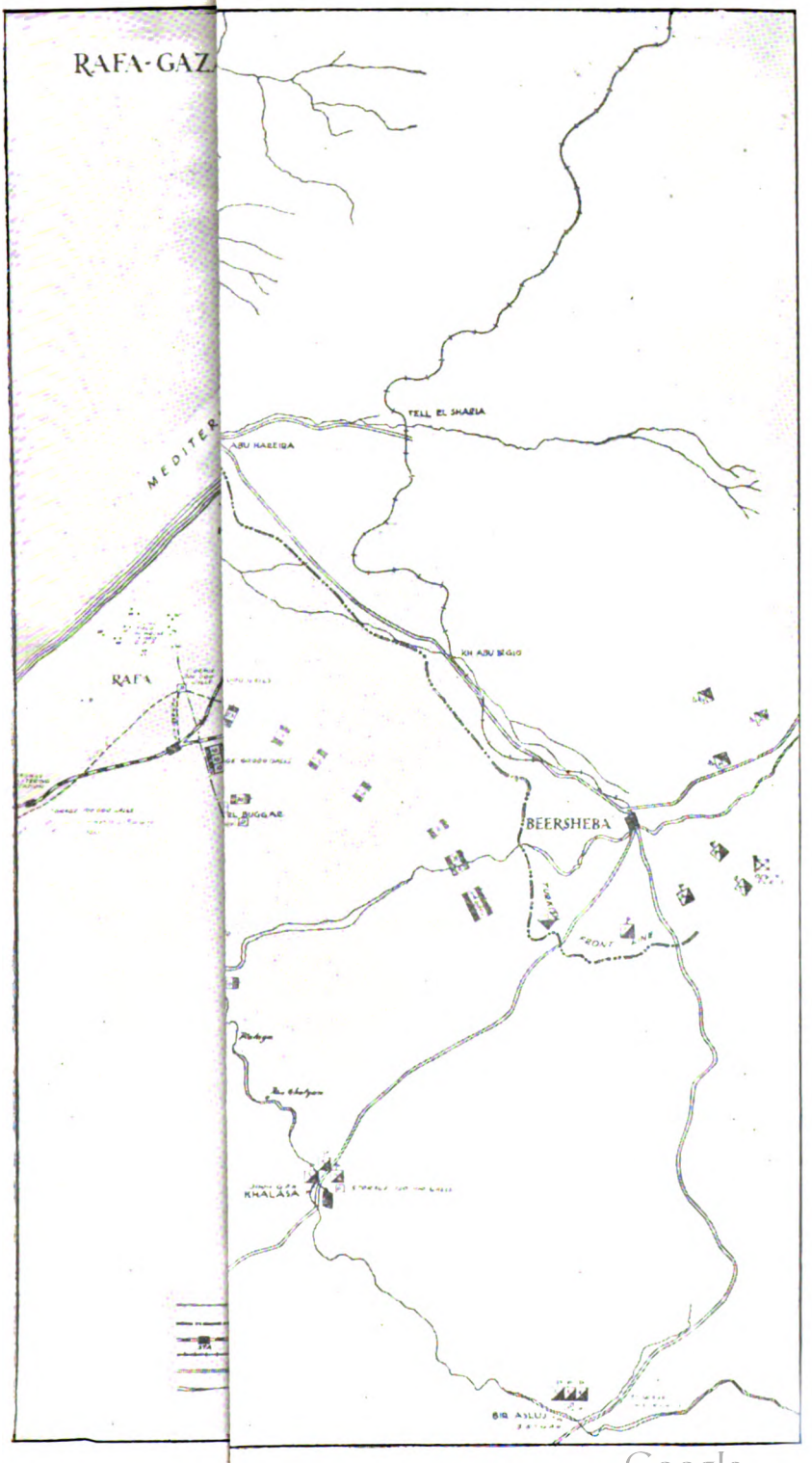
PLATE I.



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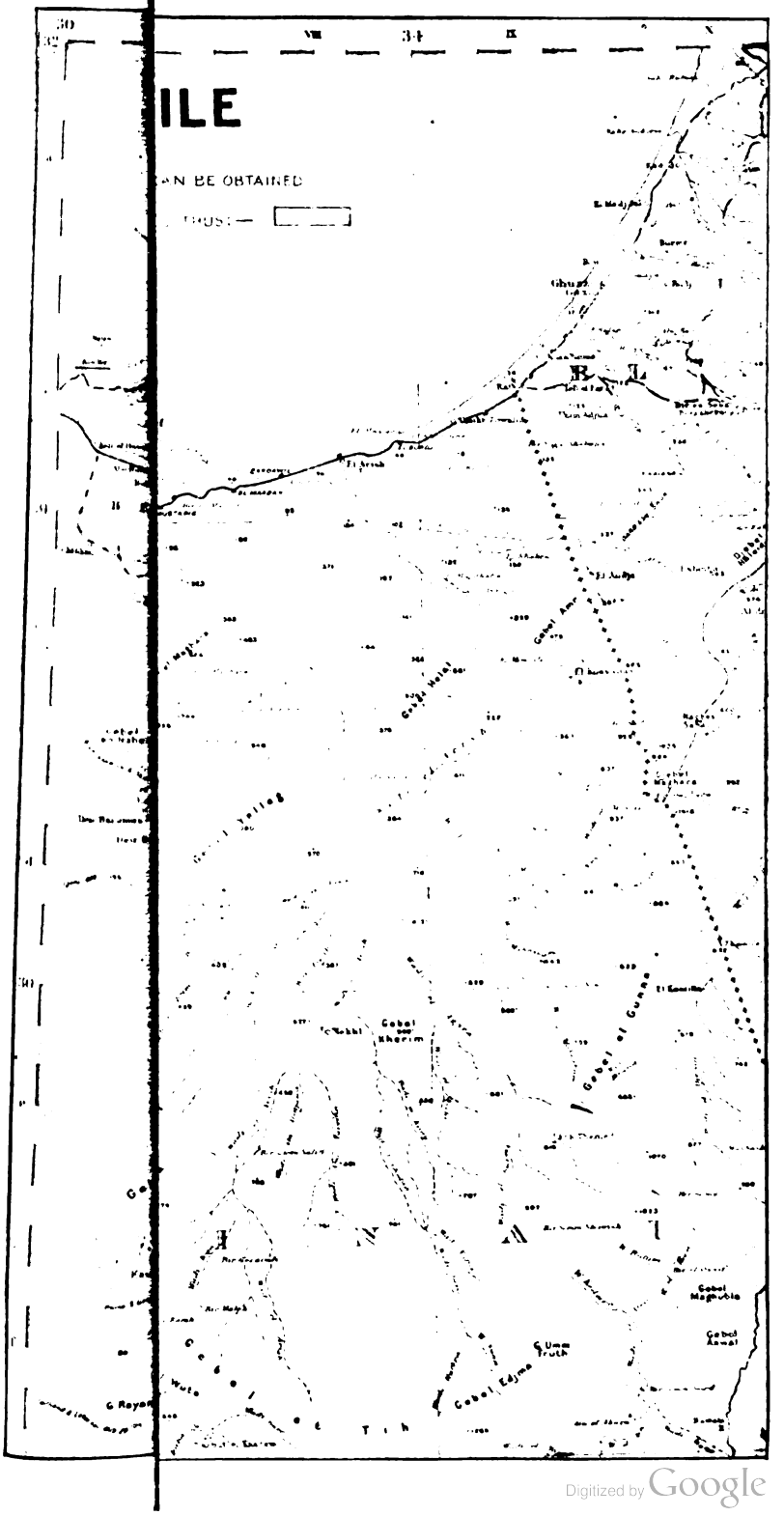

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THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914—1919.

OFFICIAL records are in course of preparation under the above title. The work is of a comprehensive nature, as will be seen from the following proposed synopsis, which is, of course, liable to alteration :—

PROPOSED SYNOPSIS.

Part I.—General. Development of the Corps. Causes that led to the formation of new branches and units. Charts to show organization and strength of the Corps in August, 1914, and Nov., 1918, etc., etc.

Part II.—Work under the Director of Fortifications and Works.

Part III.—Work in the Field under the Engineer-in-Chief, B.E.F.

Section 1. General.
„ 2. Engineer Intelligence.
„ 3. Defences.
„ 4. Bridging.
„ 5. Water Supply.
„ 6. Machinery, Workshops, Electricity.
„ 7. Mining.
„ 8. Geology.
„ 9. Inundations.
Section 10. Camouflage.
„ 11. Anti-Aircraft Searchlights.
„ 12. Foreways.
„ 13. Concrete Factories and Defences.
„ 14. Experimental Section.
„ 15. Hutting and Encampments.
„ 16. Schools.

Part IV.—Work in the Field under other Branches of the Staff (France).

Section 1. Maps.
„ 2. Gas Services.
„ 3. Forestry.
Section 4. Postal Section.
„ 5. Meteorological.

Part V.—Work in the Field in other Theatres of War.

Section 1. Egypt.
„ 2. Gallipoli.
„ 3. Mesopotamia.
„ 4. Salonika.
Section 5. W. Africa.
„ 6. E. Africa.
„ 7. Miscellaneous.

Part VI.—Work under the Director of Works (France).

Part VII.—Work under the Director-General of Transportation.

Part VIII.—Supply of Engineer Stores and material.

With the authority of the Director of Fortifications and Works the *R.E. Journal* will publish certain sections of these reports as they may become available. It is probable that they will be issued later in separate volume form, and in order that the final issue may be as complete and correct as possible, it is hoped that readers with special knowledge of any of the subjects will freely criticize the work.

It will be a convenience if such criticisms with proposals for amendments or additions are sent as early as possible to the Secretary, R.E. Institute.

In the present number of the *R.E. Journal*, Part III., Section 11, "Anti-Aircraft Searchlights," and Part IV., Section 4, "Postal Section," are published.

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ANTI-AIRCRAFT SEARCHLIGHTS.

PART III., SECTION 11.

SUMMARY OF DEVELOPMENT OF ANTI-AIRCRAFT SEARCHLIGHTS, FRANCE, 1915—1918.

1. *Resources in* 1915.—In 1915 the anti-aircraft searchlight resources available in the British Expeditionary Force consisted of Nos. 1 and 2 Anti-Aircraft Searchlight Sections with fixed equipment of three 60-centimetre projectors each. These were employed for the protection of General Headquarters at St. Omer, which was twice bombed during the winter of 1915—1916.

It is reported that on one occasion an enemy aeroplane was picked up and held in the searchlight beams for about half a minute during this period.

At this time night bombing by aeroplanes was practically unknown, and only bombing by airships was anticipated, for which the 60-cm. searchlights would have been sufficiently powerful.

2. *Additions, March—May*, 1916.—Between March and May, 1916, the following additional resources became available:—50th (Field Searchlight) Company, R.E. (Mobile), (comprising one section of two 90-cm. lights, and two sections of one 90-cm. and one 60-cm. light each); Nos. 3 to 7 Anti-Aircraft Sections, R.E. (with three fixed 60-cm. equipments each); and these resources were distributed as follows:—

1 section of the 50th (F.S.L.) Company,		Boulogne.
1 ,, ,, ,, ,,		Audruicq.
1 ,, ,, ,, ,,		Advanced G.H.Q.
No. 1 A.A.S.S., R.E.,	G.H.Q.. 1st Echelon.	
,, 2 ,,	G.H.Q., 2nd Echelon.	
,, 3 ,,	Calais.	
,, 4 ,,	Abbeville.	
,, 5 ,,	Etaples	
,, 6 ,,	Rouen.	
,, 7 ,,	Abancourt.	

3. *Bombing of Audruicq Depôt, July*, 1916.—On the night of the 22nd—23rd July, 1916, several enemy aeroplanes bombed the Audruicq Ammunition Depôt.

Only two lights of the 50th (F.S.L.) Company and two anti-aircraft guns were available at Audruicq at the time of this raid, and they were unable to render effective assistance in defence owing to the fact that the lights on the ground might have disclosed the position of an ammunition train which was being loaded. Subsequently to the dropping of the first bomb, however, the aiming became wild, and the bombs were mostly directed against the searchlights themselves.

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4. *Searchlight in Observation Balloon, Somme*, 1916.—During the first Somme Battle experiments were carried out at the front by No. 2 Section of the 50th (F.S.L.) Company and No. 1 Kite Balloon Squadron, Royal Flying Corps, with a view to mounting a searchlight in an observation balloon for the purpose of illuminating the ground. This was successfully accomplished, but the balloon itself was found to be so unsteady that accurate estimation of direction was impossible.

A new form of searchlight developed by the Royal Navy, and for which a much increased light intensity was claimed, was tested at the front by the 50th (F.S.L.) Company, and efforts were made to employ searchlights to assist infantry and artillery in active operations, but no opportunity presented itself during the battle.

5. *Bombing on Somme Front, September*, 1916.—About September, 1916, hostile bombing by aeroplanes by night began to develop in forward areas, particularly on the Somme Battle line along the Maricourt Plateau.

Machine-gunning of the roads by enemy aircraft also commenced in this area towards the end of the autumn, 1916, and as a countermeasure Nos. 2 and 5 Anti-Aircraft Searchlight Sections were ordered to the area between Montauban, Trones Wood, and the Somme. These lights were placed under the XIV. Corps Heavy Artillery, and did excellent service in forcing enemy aircraft to fly at considerable heights, and in vastly reducing the damage done. Very few targets were actually detected in the beams, however, and this fact is accounted for by the unsuitability of the equipment available, and the excessive local noises due to gunfire and transport in the forward areas, together with the inexperience of the detachments.

6. *Bombing subsequent to Somme Battle.*—Subsequently to the Battle of the Somme continuous hostile air raids were made by night along the whole of the Somme valley extending as far as Amiens.

No. 2 Section of the 50th (F.S.L.) Company, together with Nos. 2 and 5 A.A. Searchlight Sections, were allotted to this locality, and it was credibly reported, but not officially confirmed, that one enemy aircraft was shot down in the searchlight beams on the night of the 8th—9th February, 1917.

The detection of enemy aircraft in the beams was, however, an unusual occurrence at this period owing to the causes mentioned in paragraph 5 above.

7. *Reorganisation of A.A.S. Units.*—By this time Nos. 8 to 18 A.A. Searchlight Sections had gradually arrived from England, and Nos. 21 to 24 had been formed in France. These units were mainly allotted for the defence of large ammunition depôts then being formed at Audruicq, Zeneghem, Saigneville, Abancourt, and Dieppe, whilst No. 8 Section was sent to protect the Second Army Ammunition Dump between Abeele and Poperinghe.

At this period all the A.A. Searchlight Sections were reorganised on

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a basis of two lights each, because owing to the scarcity of resources it was found possible to allot only one section to any one place, and the triangle formed by three lights was generally subjected to bombing.

The various local staffs responsible for the siting of the lights did not understand their use, with the result that the searchlights usually surrounded the position to be protected, and were in consequence apt to become more of a danger than a protection.

The retreat of the enemy from the Somme Battlefield afforded an opportunity of using searchlights as a means of illuminating bridge building operations at night, and valuable work of this nature was carried out by the 50th (F.S.L.) Company at Brie-sur-Somme.

8. *Institution of Office of Inspector of Searchlights.*—In January, 1917, the Office of Inspector of Searchlights under the Engineer-in-Chief, G.H.Q., was constituted to assist in the formation and training of the units, and to advise the various staffs on the disposition of the resources.

Late in 1916 the provision of a total of 45 two-light sections had been formally approved by the War Office, and it was reported that the 60-cm. lights were not effective, with the result that the War Office authorised an entire re-equipment with 90-cm. projectors.

To save delay the *personnel* for the new units was sent to France without equipment, and this was eventually provided as it became available from England, through the agency of an equipment depôt established under the Inspector of Searchlights at Calais. The 90-cm. equipment to replace the existing 60-cm. plant was dealt with through the same depôt.

9. *Development during the Spring of* 1917.—During the spring of 1917 enemy aircraft attacks were mostly confined to the Audruicq and Calais areas.

In the former case the attacks were all unsuccessful owing to the improved anti-aircraft defences.

This period and the early summer of the same year were devoted to the training of the new *personnel*, equipment of the units, and co-operation with anti-aircraft artillery.

A mechanical control for the searchlight projectors was developed without which the useful action of the lights would have been almost impossible. By means of this device the projector controller was situated some 12 to 14 feet from the projector itself, and was thus able to see the target in the beam.

10. *Bombing during Summer of* 1917.—During the early summer of 1917 enemy aircraft extended their attacks to the Isbergues Steel Works, Arras, St. Omer, Audruicq, Calais, and the Second Army area. The searchlights had by this time begun to detect and hold enemy aircraft in their beams, but still further experience and training were required to make the *personnel* throughly efficient. In July, August, and September, 1917, very heavy night bombing was

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experienced in the XV. Corps area on the coast behind Nieuport, and in the Second and Fifth Army areas in the third battle of Ypres. Two sections of 50th (F.S.L.) Company, and fourteen A.A.S. sections were accordingly concentrated in this area.

The lights thus concentrated then began to work with great efficiency, and in spite of the misty atmosphere prevailing in this low-lying country it is reported that between 50 and 60 per cent. of raiding aircraft were detected and held in the beams. Several enemy aircraft were destroyed by anti-aircraft gunfire, and many were driven off.

All enemy aircraft were forced to fly at heights of 6,000 to 12,000 feet, with the result that the casualties were reduced to the minimum which might be expected from indiscriminate bombing of a large area.

11. *Lighting of Ypres Area.*—The use of lights in the forward area was then developed on a line between Ypres and Brielen. The searchlights themselves were very severely bombed, and the provision of suitable earthwork protection for the *personnel* was perfected. Eventually, although casualties were still caused by shell fire, the efficiency of the earthwork protection was such that no casualties were caused by the effect of bombs when the men were actually under cover.

The detachments showed great determination and courage in keeping the searchlights directed on to enemy aircraft whilst being heavily bombed, a result which there is evidence to show the enemy were never able to achieve in their own anti-aircraft defences.

12. *Lighting of Bethune Area.*—In the autumn of 1917 the Isbergues Steel Factory and the Bethune area were consistently bombed, and four A.A. Searchlight Sections were allotted for the protection of this locality.

The action of the lights was not entirely effective owing to the fact that they had to be scattered in an effort to cover the whole area, whereas in this very misty locality close concentration was essential for effective operation. Enemy aircraft, however, rarely flew at lower altitudes than 10,000 feet.

Throughout the year attacks on Audruicq and Zeneghem were continually being made, but the anti-aircraft defences were sufficient to prevent any serious damage being done.

13. *Reorganisation Committee.*—During this period the whole question of anti-aircraft protection again became pressing, with the result that a G.H.Q. Committee was formed with representatives of Major-General Royal Artillery, Engineer-in-Chief, Director of Signals, Royal Flying Corps, and Machine Gun Corps.

This Committee took evidence at Army Headquarters from all who wished to express their views. Army Commanders, Corps Commanders, Divisional Commanders, General Officers Commanding R.F.C. Brigades, Directors of Signals, General Staff, and M.G.R.A.,

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were examined, with the result that a comprehensive report was made, containing recommendations as to the lines on which anti-aircraft development should proceed. An increase of 30 anti-aircraft sections was authorised as an initial measure. Owing, however, to the shortage of men at the time it was found possible to provide only about 30 per cent. of the additional *personnel* (men of medical category "A") from England, the remainder being found in France from category "B" *personnel* transferred from the infantry, and trained in the existing A.A. Searchlight Sections.

Authority was subsequently given for the addition of a third light to each Anti-Aircraft Searchlight Section then approved, the *personnel* being found partly from "A" men from England and partly from "B" men transferred from infantry in France.

As a further result of the G.H.Q. Anti-Aircraft Committee an Assistant Inspector of Searchlights with the rank of Major was authorised for each army, and for L. of C., with the rank of Captain.

14. *Progress of Expansion of Lights.*—The expansion to provide an additional 135 lights was in progress during the whole of 1918, and the Inspector of Searchlights arranged to form the whole of the 30 new A.A. Searchlight Sections referred to above by withdrawing experienced N.C.O.'s and men from the older sections in France, and by the dilution of the establishments with category "B" men. This operation, which then became universal, entailed much work in connection with equipping and training the new sections.

Simultaneously, twelve additional 3-light sections were authorised for the protection of the aerodromes of the Independent Air Force, none of which became available, however, before the Armistice.

15. *Employment of First Night-fighting Squadron, R.A.F.*—In the autumn of 1917 it had been foreseen that it would be necessary to use night-fighting aeroplanes to attack enemy aircraft, and a letter had been put up through the Engineer-in-Chief and General Staff to the Royal Air Force requesting that this should be arranged. About June, 1918, No. 151 (Night-Fighting) Squadron, R.A.F., became available for employment with the anti-aircraft resources in the B.E.F. This squadron was at first used in connection with a series of outpost lights in front of Abbeville, but the experiment was unsatisfactory owing to the fact that the area was not sufficiently extensive, and very few combats were reported.

Several more night-fighting squadrons had been authorised, only one of which became available before the Armistice.

16. *Provision of Mobile Generating Sets.*—At the time when the proposal for night-fighting squadrons was put forward it was decided to ask that all additional searchlights should be 120-cm. projectors. Further, the provision of mobile searchlight equipments previously vetoed, had by this time been proved to be absolutely necessary, and all additional equipments were accordingly made mobile by the introduction of petrol-electric lorries.

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These mobile generating sets are of a complicated and highly technical nature, and it was considered advisable to select, and train, as drivers, suitable men from amongst the skilled mechanics in the Searchlight Sections. This training was carried out in France.

17. *Forward Area Bombing, February*, 1918.—During the winter of 1917 enemy bombing at night had been slight, but about February, 1918, heavy bombing began to develop in the Third and Fifth Army areas, where the 50th (F.S.L.) Company, and 14 A.A.S. Sections were then concentrated.

The forward areas thus covered were full of troops and horse lines concentrated in anticipation of attack by the enemy.

The action of the lights and guns was so effective that enemy aircraft rarely penetrated the areas, with the result that the casualties were comparatively small. In some cases the searchlights were able to pick up every enemy aircraft which approached the area.

18. *Defence of Railway Junctions, March*, 1918.—In March, 1918, when it became evident that attack by the enemy was impending, anti-aircraft protection was hastily improvised for the important railway junctions at Hazebrouck, St. Pol, and Doullens as follows :—

Two A.A.S. Sections at Hazebrouck.
Two A.A.S. Sections at St. Pol, and
Four A.A.S. Sections at Doullens.

19. *Bombing during German Advance, March—April*, 1918.—During the battles of March and April, 1918, forward areas in the First, Third, and Fifth Armies were heavily bombed, and owing to the fact that most of the lights in these areas were fixed, 14 sets of equipment were captured by the enemy, during his advance.

Such mobile equipments as were available were maintained in action continuously within 2,000 to 5,000 yards of the line, and particularly in front of Amiens, Albert, and Isbergues. These lights rendered very valuable service in co-operation with the anti-aircraft artillery.

The railway junctions referred to above were heavily attacked, but the anti-aircraft protection was apparently a surprise to the enemy, and his action was so much hampered that no serious damage was done to these vital points.

20. *Bombing of Bases, etc.*, 1918.—During April and May, 1918, heavy attacks were made on Abbeville, Abancourt, Etaples, Boulogne, Calais, and Audruicq.

Except in the case of the last mentioned, where considerable resources were available, great damage was caused, and this is attributable to the fact that the anti-aircraft defences were entirely inadequate.

During, August, September and October, the First, Third and Fourth Army areas were heavily bombed, and A.A. Searchlight Units were accordingly distributed as follows :—First Army, 9

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Sections; Third Army, 5 Sections; Fourth Army, 50th (F.S.L.) Company, and 5 Sections.

21. *Organisation of Lighted Belt on New Front.*—A captured German document shows that the enemy reported very heavy bombing on the troops, etc., assembled in the Anzac Corps area in the Hallue Valley on the night of 21st—22nd August, 1918.

The searchlights had, however, been pushed up in front of this area on the night previously, so that the bombs fell in advance of the troops and no damage was caused.

Subsequently all available lights were pushed as far forward as possible, the foremost line being from 2,000 to 6,000 yards from the trenches, and eventually the lighted belt was extended along the whole front and provided with rows of searchlights two, three, and four deep.

No. 151 Squadron, R.A.F., working in conjunction with this belt of lights were able to destroy in flames some 25 enemy aircraft on our side of the line, with the result that in the end the bombing was limited to the areas in front of the foremost line of searchlights, the back areas being almost completely immune.

Severe casualties were caused in places where lights were not available, but the gaps in the lighted belt were closed as soon as practicable by new units hastily formed as the equipment arrived from England, or by old units from L. of C. which had been replaced by newly formed sections; and eventually the casualties from hostile night bombing were reduced to a minimum.

Lights were frequently in action at the front within two or three days of their arrival at Calais from England.

22. *Use of Lights during Final British Advance.*—The general retreat of the enemy during the closing stages of the war again afforded opportunities to utilise searchlights for illuminating bridge building operations at night, and much valuable work of this nature was carried out.

It was also reported that the lights had been used in the forward area near Mons in connection with railway construction work. One searchlight had been placed at each end of a mile of railway track, and the beams aligned at an angle of about two degrees elevation over the working parties. By this means the whole length of track between the two searchlights was illuminated sufficiently for the parties to work at night.

From time to time during the course of the war the lights have, in addition, been used to assist in trench raids and other minor operations as recall signals and aids to direction.

23. *Anticipated Development if War had gone on.*—An additional sixteen 3-light sections had been approved in the late autumn of 1918, and were almost ready for action at the time of the Armistice.

If the war had gone on, an illuminated barrier, four lights deep, would have been established down the whole British front, and it is

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believed that the anti-aircraft defences in back areas could then have been considerably reduced, with the exception of those in the area between Calais and the line.

It is thought that the efficient sound locators, suitable night binoculars, and more powerful searchlights which had become available, in conjunction with the high standard of training attained by all ranks, would have rendered the searchlights capable of dealing successfully with enemy aircraft at whatever height they might have flown in the future.

24. *Personnel of A.A.S. Sections.*—The *personnel* with anti-aircraft searchlights, which amounted to some 3,000 all ranks at the end of active operations, was found very largely from the London Electrical Engineers and the Tyne Electrical Engineers, with a proportion of regular Royal Engineers, and about 600 men of medical category "B" transferred from the infantry.

25. *Training of American Units.*—During the course of 1918 over 1,000 officers and other ranks of the American Engineers were attached to the British Searchlight Units in Army areas for instruction, pending arrival of the American technical equipment. This *personnel* co-operated very closely with the British detachments, and the increased numbers thus available were of the greatest assistance during moving warfare, which necessitated much work in moving heavy weights and digging earthwork protection. On return to their own army the American *personnel* thus trained were very soon able to render effective service with their own equipment during the course of the battles in which the American Army was engaged.

An Anti-Aircraft Company of Canadian Engineers, consisting of 12 mobile 90-cm. projectors was formed in July, 1918, and rendered good service; and had the war been prolonged throughout the winter of 1918, it is probable that the Australian Corps would also have formed an Anti-Aircraft Searchlight Company from Australian Engineer *personnel.*

26. *Conclusion.*—Experiences in France have shown that an Anti-Aircraft Searchlight Detachment requires the best equipment, a high standard of training, and, wherever possible, complete freedom in control of action. An elaborate system of "central control" such as has sometimes been found necessary in connection with the defence of large ammunition depôts, has undoubtedly hampered the working of the lights in action; and it is therefore suggested that they should be developed independently of the anti-aircraft artillery, as their work in the future will lie more and more in co-operation with night-fighting units of the Royal Air Force.

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POSTAL SECTION.

PART IV., SECTION 4.

ARMY POSTAL SERVICES.—ROYAL ENGINEERS SPECIAL RESERVE (POSTAL SECTION).

1. *Introduction.*—It has been accepted as an axiom that the effect of a good postal service upon the *morale* of the troops is of inestimable value.

The manual of Army Postal Services, revised in 1913, lays down the elementary principles governing the Postal Service of an Army in the Field. These principles have in the main amply stood the test of experience, although the proportions which the service assumed in the war necessarily led to considerable amplification of the original machinery.

2 *Initial Operations.*—As will be seen from the Appendix the original establishment of the Postal Section of the R.E. Special Reserve was extremely small. The Postal Units comprised :—

1 Base Office.
1 Advanced Base Office.
2 Stationary Post Offices.
1 Field Post Office with General Headquarters.
1 Field Post Office with H.Q. Inspector-General of Communications.

Divisional Offices.

Field Post Office with each Divisional Headquarters.
Field Post Office with each Brigade Headquarters.
Field Post Office with each Divisional Train.

The advance parties of the Base and Advanced Base Post Office Staffs embarked for France on the 11th August, 1914, followed by the remainder on 15th August.

The Field Postal Units proceeded with the formations to which they were attached.

The Base Post Office was established at Havre, and the Advanced Base Post Office at Amiens.

On the 27th August, owing to the retirement of the forces after the battle of Mons, the Advanced Base was transferred from Amiens to Rouen, and a few days later to Le Mans, the base having been moved to Nantes in the meantime.

The fortunes of the Postal Service in the field during the retirement followed those of the army generally. Such business as came to hand

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was transacted by the Field Post Offices attached to the various headquarters, but owing to the change of base, no mails could be sent forward to the troops at the front for more than a week.

At the time of the first battle of the Aisne the Advanced Base of the Army Postal Service was at Livveneuve St. Georges (near Paris), and as the position stabilized arrangements were made to re-establish the Postal Base at Havre with a regular service from Southampton. This was brought about on the 28th September, and a marked improvement was effected at once. On the 14th October the Advanced Base moved forward to Abbeville.

At the beginning of October, 1914, an Auxiliary Postal Base at Ostend was established to serve the portion of the army operating in Belgium, but military events precluded the use of this base for more than a few days.

3. *Christmas* (1914) *Traffic.*—The first Christmas presented a serious traffic problem. There was no previous experience to go upon, and it was impossible to form any estimate of what the volume of mail matter was likely to be ; moreover the resources in the matter of staff and transport were extremely inelastic. In anticipation, however, of a very large increase the staff was temporarily increased from 900 to 1,500, and 50 additional motor lorries were obtained from England. The actual increase was about 90 per cent. in letters and 345 per cent. in parcels.

4. *Improvements in* 1915.—In the new year, 1915, several important improvements were effected having for their object the acceleration of the mails both to and from England.

It became clear that the growth of the army, coupled with considerations of transport precluded the maintenance of a base sorting office for English letters and parcels in France for any lengthy period. The only solution was the complete sorting of the mails in England, thus admitting of the diversion of those for any particular unit to any port, the work in France being limited to the distribution of the unit bags received from England and to " cross-post " (intercommunication) and local traffic. Arrangements were therefore made for a gradual transfer of the English sorting work to the Army Postal Depôts in London. By the 8th February this had been accomplished, and the whole of the mail traffic transferred to the Boulogne route. Later on provincial concentration offices in England were established as auxiliaries to the London depôts.

At a later stage it became necessary, owing to the growth of the army and for transport convenience, to divide the cross-channel traffic between Boulogne, Calais, and Havre.

5. *Inter-communication Services.*—The enormous growth of postal inter-communication between the various parts of the army necessitated the setting up of machinery by means of which expeditious

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circulation could be secured. Up to the end of November, 1914, the absence of railway facilities suitable for such purposes, and the lack of mechanical transport on lines of communication and between formations in the field, gave rise to great difficulty.

The railway supply routes, while serving for the transmission of mails from the bases to railheads, were of no use for "cross-post" services. Road services were accordingly organised. These services were not of course stable in nature; they changed daily with the varying incidence of troops movement, and unquestionably the most difficult problem with which the Army Postal Service had to deal, was the maintenance of a vast system of interwoven road and railway services which at any given time, and under any circumstance incidental to warfare could be relied upon to ensure the speedy transmission of correspondence between one portion of the army and another. It is estimated that at the peak of the traffic as many as five millions of letters a week, official and private, were so dealt with, and it is claimed that speaking generally the normal time occupied in transmission of a letter from one part of the line to another, or to and from the L. of C. (excluding of course the more distant points, *e.g.*, as Marseilles, Taranto, etc.) was 24 hours.

6. *Development of Army and Corps Troops Services.*—Up to about the middle of 1916 Stationary Post Offices existed only on lines of communication. The development of the military situation, however, involved the emplacement of large numbers of extra Army and Corps Troops (such as heavy and siege artillery, labour companies, tunnelling and road construction companies) of a semi-stationary nature in army areas. On one army front alone there had grown up by July, 1917, extra troops of this description equivalent to the population of the town of Southampton, and the mobile post offices attached to headquarters of field formations were unable to cater for these vast agglomerations.

Post offices of a semi-stationary character were accordingly established in army areas for the purpose, and it would be no uncommon thing for an office of this description to receive from 400 to 500 bags of mail and despatch some 30,000 letters daily in addition to large transactions in postal orders, war savings certificates, and registered letters.

7. *Accommodation.*—The provision of accommodation for post offices, particularly in the devastated areas, afforded opportunity for the exercise of considerable ingenuity and architectural fancy. It would sometimes take the form of a regulation hut, or collection of huts and tents, but more often than not shift would be made with a ruined building, an abandoned "dug-out," or even a few tarpaulins more or less effectively draped over a structure of old biscuit boxes or petrol tins. But few standard fittings existed,

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except at the large permanent depôts; canvas sorting racks and various tin boxes formed part of the equipment, but it was generally found convenient to improvise fittings from local resources which could be "scrapped" on evacaution.

It may not be out of place at this point to quote the following extract from an article in the *Daily Mail* of the 22nd September, 1918, from the pen of John Pym, entitled "The Black Box," which provides a graphic and accurate picture of the mobile field post office.

"A Field Post Office is primarily an iron box—not a building; a black, heavy box, under the care of a corporal and two sappers. The box holds postal orders, stamps, cash, lead seals for mail bags, rule books, and scores of other items—not forgetting the red-and-white flag of office. This box may be lodged anywhere—in an open field, a barn, a stable, a tent, cellar, dug-out, or a chateau; but wherever it is dropped there is the field post office."

8. *Organisation of Directorate.*—At the outset the directorate comprised a director and deputy director at Headquarters, with assistant directors with each Army Corps. Later on assistant directors were appointed at the headquarters of each Army with deputy assistant directors with each Army Corps, and the whole service was sub-divided for purposes of administration into two sections, each under a deputy director, as follows:—

Northern—including the northern armies, ports, and lines of communication.

Southern—including the southern armies, ports, and lines of communication

Assistant directors were appointed to H.Q., L. of C., and at the Base Ports.

With each division was a warrant officer, who was responsible under the deputy assistant director at Corps Headquarters, for the whole of the internal postal organisation of his division.

9. *Cross Channel Services.*—The ordinary mail boats were used up to their fullest capacity at all the ports, cargo boats and transports being used for the conveyance of the surplus parcel mails.

The volume of mails dealt with at the different ports varied from day to day according to the geographical distribution of the troops, and to the requirements of railway traffic.

10. *Distribution of Newspapers, Letters, and Army Publications, and Stationery by Express Road Services.*—A branch of the work of the Army Postal Service which was regarded as of great importance to the welfare of the troops was the distribution of newspapers.

Subscribers' newspapers which could not be posted in London in time for inclusion in the mail bags were sent out in bulk to Boulogne

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with the mails, and there sorted and included in special express despatches. These express services were provided by a number of lorries which left Boulogne about one hour after the arrival of the Mail Packet. In addition to the afore-mentioned despatches they carried the letter mails from England for the headquarters of all formations in the field, and also the free newspapers for the troops. By this means it was very largely possible to deliver papers at headquarters of armies, corps, divisions, and brigades on the day of publication; or in the more distant areas the next morning.

In the reverse direction the transport was used to carry all letters for home from the troops in the field. These mails reached the base port in time to secure despatch to England on the morning after they were posted.

A very large volume of printed matter and stationery issued by the Army Printing and Stationery Services, averaging about 10 tons a day, was distributed by the Army Postal Services.

11. *Dominions and Allied Services.*—Associated with the British Army Postal Services were contingents from the following Dominions and Allied Countries :—

1. Indian.
2. Canadian.
3. Australian.
4. New Zealand.
5. South African.
6. Portuguese.
7. Central American Units.

12. *Postal Contingent for Other Theatres of War.*—Early in 1915, the Mediterranean Expeditionary Force was formed, and several postal officers were sent from France. The postal staffs for the Salonika and Egyptian Forces formed later on were largely provided from the B.E.F. establishment.

In November, 1917, the Italian Expeditionary Force was formed from troops in France.

The field post offices accompanied their respective divisions, and officers and other ranks to provide for the direction and lines of communication services were found mainly from France.

Finally a postal contingent was provided from the B.E.F. for the North Russian Expeditionary Force in August, 1918.

The mails for the Salonika, Egyptian, and Italian Forces were mainly transmitted through France.

13. *German Offensive, Spring,* 1918.—The organisation briefly sketched in the foregoing pages enabled the postal service to meet successfully the calls made upon it throughout the varying phases of trench and offensive warfare. Considerations of space preclude

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any description of its operations up to the opening of the great German offensive of March, 1918. The enemy attack of this date in the direction of Amiens and the consequent retirement of the Third and Fifth Armies imposed perhaps the most serious test on the organisation of the Army Postal Service throughout the whole campaign, and it may therefore be of interest to give here a brief statement of the proceedings during that period culled from the official diaries.

Since the withdrawal from Belgium to the Marne in 1914, when the organisation of the Army Postal Service was in an elementary stage, the British Army had not been involved in any movement of a retiring nature, and all preparations for such an event were based on theory rather than practical experience.

It was realised that all the military difficulties inherent in a retirement would have their postal counterpart, and that the task of grappling with the problems of an advance were simple in comparison with the difficulties which would be met with if and when the forward postal lines of communication became suddenly broken or were pressed back on or behind the advanced concentration centres.

At the commencement of the battle nearly all brigade field post offices were transferred from brigade headquarters to the appropriate company of the divisional train in accordance with standing orders. It soon became evident that fighting units would be unable to accept delivery of all their mail, particularly parcels. This was anticipated from the commencement because of the experience gained in previous operations; but the conditions called for different action. During offensive operations divisions could not be cumbered with heavy mails for a day or two, and it had been customary in such circumstances to establish divisional mail dumps in the field and not to interfere with the normal flow of mails from the base to railhead; but to follow such a course during a retirement would have been to court disaster. Accordingly, when it became evident that a particular formation could not accept mails it was arranged to re-consign them to the base, and to stop further consignments from being sent up. These mails were mainly parcel mails, as in many cases it was possible to effect delivery of the letters. By the 29th March some 20,000 bags had thus accumulated, and as divisions were withdrawn from the battle, the mails were sent up to them.

The cross post and express services for headquarters of formations were generally maintained without delay, and the collection and disposal of postings were effected with regularity.

A point of general interest was the great popularity of the field service postcard. The troops generally were too unsettled to write many letters, but they were keen to get field service postcards away.

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One division reported that " whenever our lorries passed troops on the road we were assailed with requests for F.S. postcards." Fortunately the post offices were able to distribute their reserve stocks.

On the 21st March the whole area of the Third and Fifth Armies was subjected to a heavy bombardment, and a certain amount of dislocation of services resulted from the sudden suspension of train services, and the destruction of or damage to railhead and other post offices. The distribution mail train running *viâ* Albert to Arras and Doullens stopped at Albert, and did not make the return trip. The outward mails were distributed from Albert by lorry, and formations in the Arras area were linked up by lorry with St. Pol. The Foreste Section truck was stopped at Nesle and was cleared there.

Railhead post offices at Arras, Boisleux, Achiet, Bapaume, and Roisel had to be hurriedly evacuated. Arras was heavily shelled and roads became blocked with débris, making it difficult to get mails to some of the offices. One of the postal lorries got fixed in a shell hole, and a corporal in charge of the postal column was severely wounded and died a few days afterwards.

At Achiet, the post office hut was destroyed, and the divisional postal lorries were destroyed by shell fire. Other lorries were obtained, and the services were maintained. Two sappers were severely wounded, but work was carried on in an adjacent post office, which was also destroyed later after it had been evacuated. At Bapaume work had to be suspended for periods, and one sapper was wounded by shrapnel. The post office hut at Bertincourt was destroyed by a shell, the mails, date stamps, etc., were recovered, but unfortunately a sapper was killed outright. Etricourt, though well forward, escaped, and mails were delivered and despatched in normal course.

Roisel suffered heavily, and the place had to be left in a hurry. Two post office huts were damaged and a sapper gassed. Of the postal lorry drivers, one was killed and two were wounded. The mails and stock were saved, but the fittings and personal kit were abandoned. One divisional railhead post office had to leave mails behind as well as equipment, because one of the lorries had been hit by a shell, but the warrant officer in charge obtained a lorry and returned and recovered the mails. Meanwhile the incoming supply train had been stopped at Tincourt, where the mails were drawn and disposed of. But here also the conditions became serious. The railhead P.O. was struck by a shell, and the whole of the staff except one were wounded. The supply column corporal was also slightly wounded, but he refused medical attention, and took over the duties of the warrant officer, who had been wounded. With his two

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pioneers and the surviving member of the staff he carried on the work of the railhead office and the division generally until reinforcements arrived.

Foreste and Flavy le Martel railhead post offices had to be abandoned in face of the enemy advance.

On the 22nd, 23rd, and 24th March the rearward movement continued. The cross-country mail train continued to run as far as possible. Work at the postal depôt at Albert was interfered with by continuous bombing raids, but all despatches were made as usual. During the day all offices at Peronne were withdrawn. Mails and records were brought away, but two offices had to leave all fittings behind. The N.C.O. who had to evacuate his office at Bertincourt the previous day, obtained a lorry during the morning and tried to return to salve the office equipment, fittings and kit, but was forced to abandon the attempt owing to heavy fire. At 3 p.m. he made another attempt with four volunteers and in spite of heavy fire managed to recover everything of value.

The most critical period from a postal point of view had now arrived. The principal Third Army postal depôt at Albert found itself almost in the front line; the Fifth Army depôt at Amiens was working under serious difficulty caused by heavy bombing at night, and the depôt at St. Pol was also disturbed for the same reason. The postal distribution trains ceased running. The postal depôt at Albert found itself unable to carry on owing to continuous bombing and machine-gun fire from aeroplanes; the town had already been evacuated by civilians. A truck with undelivered unit mails was accordingly made up in haste and despatched by the last train to leave. The outgoing and cross post mails were sorted during continuous air raids, and a complete despatch was made by lorry *viâ* Amiens. The office had then to be abandoned, but all records and stocks were successfully removed.

The enemy thrust for Amiens had now developed into a wheel southwards towards Compiègne and Paris, and the southern railheads at Appilly and Noyon were compelled to fall back to Compiègne and Estrée St. Denis. The Third Corps had passed under the command of the Third French Army, and in view of the distance from any postal depôt and the difficulties of telegraphic or other communication, its postal service was subjected to greater vicissitudes than that of any other Corps. The train mails had been held up, but express and inward cross post mails were delivered *viâ* Amiens until the 28th March. Thereafter direct communication was severed and express mails suffered some delay while they were being diverted to the supplies route. It is satisfactory to note that no mails were lost or abandoned, and that outgoing mails were despatched regularly.

By the 28th March the retirement had slackened speed considerably

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and had practically ceased except in front of Amiens, where Boves and Longueau railheads were evacuated, and the post offices were moved west of Amiens, and by the 30th the work of disposing of the accumulation of unit mails was well in hand. When this was completed matters may be said to have become normal.

In spite of the rapidity of the enemy advance it is very satisfactory to note that although approximately 250 post offices were involved very little material was lost.

As far as can be ascertained there was only one instance of actual loss of mails. A certain division had dumped their mails for delivery with supplies when orders were given for immediate evacuation of the place. The only lorry available was packed with bags and sent back, the remaining 50 bags being left behind in the care of the military police. These bags were subsequently placed on passing transport under orders of the A.P.M. The bulk was handed back to the post office soon after, but 13 were not returned until 6th April, and three were not recovered.

The enemy offensive which opened on the 9th April on the Armentières-Béthune front led to similar experiences. Railheads of two divisions were very heavily shelled while the loaded mail trucks were in the station. Attempts were made to clear the mails, but only with partial success; some of the postal lorries were destroyed in the process and the railhead had to be evacuated. It was hoped that it would be possible to salve the remainder of the mails when the fire subsided, but although repeated attempts to recover the mails under heavy shell fire were made, recovery proved impossible, and as the enemy forced the line back to the river Lys the same day, it must be presumed that the mails fell into enemy hands, or were destroyed by shell fire. During these operations post offices at such advanced points as Merville, Bailleul, Béthune, St. Venant and Caestre had to be moved back. The large army postal depôts at Lillers and Morbecque had also to be withdrawn, the intervening roads being under continuous shell fire, while the withdrawal in the Ypres salient towards the end of the month, and the interjection of a French Force, necessitated considerable revision of the postal services of that part of the line. After the serious repulse of the Germans on the 29th April the position became more stable. The back areas were continually subject to shell fire, however, and work was carried on at railheads under a certain amount of difficulty. Proven and Poperinghe areas suffered particularly in this respect. The Proven railhead was so heavily shelled that instructions for its evacuation were given. The divisional supervisor and two N.C.O.'s returned however, and cleared the mail track by carrying the bags to the protection of a sandbank under heavy fire. They then fetched a lorry, removed the bags and effected delivery at the normal time.

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14. *British Advance*, 1918.—The events of the later months of 1918 created many serious problems for the army postal service. The whole front was in a fluid state and the continuous advance of our victorious troops involved constant re-arrangement of main cross post services and forward movement of army depôts, in some instances to the actual premises they had evacuated a few months earlier, and in others to premises which had been used by the Germans for the same purpose for years. The consequent lengthening of the main services imposed a severe strain on the limited amount of transport available. Further forward in the field the army postal *personnel* had experience in maintaining services for an army advancing against an enemy who was resisting stubbornly and systematically destroying all roads, railways and bridges, either at once or by delayed action fuzes. Under these conditions it was necessary to maintain services in total darkness because of the activities of enemy aircraft. As the advance proceeded the distances between railheads and refilling points increased because the troops outstepped the advance of railheads. The lorry services were then subjected to great strain, *e.g.*, when one corps had reached the line of the Scheldt their railheads were as much as 30 to 35 miles back. In such circumstances it was extremely difficult to avoid delay, not only to mails carried between supply railhead and refilling point, but to the whole of the cross post and express services. Nevertheless the services generally were maintained with but few failures, and there were no instances of serious dislocation.

The corps which advanced from Poperinghe across the stretch of mud and devastation past Passchendaele to Courtrai was in a difficult position as regards road services. When they were beyond reach of the road centre at Poperinghe a light railway service was organised from the terminus of the road service at Poperinghe across to Passchendaele. This was used for mails, and worked satisfactorily until the devastated belt was passed, and a road service could be organised southwards *viâ* Bailleul and Armentières to Roncq, where a distributing centre was established.

Pending a resumption of the French and Belgian civil postal services, arrangements were made to afford postal facilities to the civil population in the area round Lille and in Belgium.

15. *Aeroplane Services.*—Aeroplane services were established in December, 1918, between the base and Cologne and intermediate stations, the longer stages being used for " through " traffic, and the shorter stages for local traffic. In March, 1919, the first overseas service from Folkestone direct to Cologne was instituted.

16. *Travelling Post Offices.*—In December, 1918, a travelling post office was established on the Boulogne-Cologne express, English railway sorting carriages being imported for this purpose.

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The advance of the forces into Germany had imposed on the postal services one of the heaviest strains of the war, and in order to keep up the inter-communication and express services the organisation of a chain of lorries from Boulogne to Cologne had hitherto been necessary. The difficulties were increased by the fact that the roads running through the battle area were in very bad condition. The establishment of the railway travelling post office afforded therefore much relief.

17. *Parliamentary Elections.*—The army postal services rendered material assistance in connection with the following Parliamentary Elections :—

Australian Commonwealth Federal Election, April, 1917.
Alberta (Canada) Parliamentary Election, August, 1917.
Saskatchewan (Canada) Parliamentary Election, September, 1917.
Canadian General Election, December, 1917.
Australian Military Service Referendum, December, 1917.
United Kingdom General Election, December, 1918.

In each case special arrangements were made by the Army Postal Services for the delivery of the ballot papers to the troops concerned and for their subsequent collection and delivery to the returning officers.

In connection with the Dominion Elections, the following letters were received by the Director of Army Postal Services :—

(1). *From the Presiding Officer, Canadian Elections in Europe.*

" I have the honour to express my appreciation and thanks for the assistance rendered by you during the past month, when I was charged with the responsibility of supervision and control of the arrangements for the Canadian Elections among the forces in the field.

Had it not been for your co-operation, it would have been impossible for me to complete my work."

(2). *From the Australian Commonwealth Returning Officer.*

" On behalf of the Government of Australia I wish to express my keen appreciation of the excellent postal facilities afforded during the recent Australian Referendum.

The fact that this Australian Referendum occurred during a period when the postal services were rushed with Christmas work makes the exceptional results obtained even more remarkable.

Accept my sincere appreciation."

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The United Kingdom General Election, occurring as it did during the Christmas postal pressure and the advance of the British Armies to the Rhine, threw a considerable strain upon the Army Postal Services. The great portion of the election circulars secured delivery to the addresses before the arrival of the ballot papers. Ballot papers correctly addressed were delivered to the military voters within from one to three days after receipt at the base ports in France, according to the disposition of the troops, a large number of whom were then in Germany. An appreciable percentage of the ballot papers were, however, incorrectly addressed and required a second or third handling by the Army Post Office, as they followed men who had moved from formation to formation.

Just as the election pressure began to manifest itself the Army Postal Services were asked at brief notice to undertake delivery to the troops of very large quantities of free newspapers in order that the military voters might have information on which to base their decision when exercising their votes. Over 3,000,000 newspapers were distributed to the troops. The distribution in the back areas was completed the day following the receipt of the newspapers at Boulogne, and in the most advanced areas all newspapers were delivered three days after receipt in the country.

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APPENDIX.

ARMIES IN FRANCE AND BELGIUM ONLY, 1916.

Number of Mobile Field Post Offices	412	At the beginning of the War the numbers were 30 and 4 respectively.
Number of Stationary do. ..	111	
Staff of Army Postal Services ..	Officers, 55 Other Ranks, 2970 Men attached for unskilled duties, 500	
Number of bags of mails received from England weekly	Letters, 38,500 Parcels, 84,000	At the beginning of the War the weekly number of bags was approximately 2,000
Number of letters received from England weekly	11,000,000	
Number of letters despatched to England weekly.	9,000,000	
Number of parcels received from England weekly	850,000	During Christmas week 1916 the number was 5,250,000. The parcel traffic began to decline about the middle of 1917 probably owing to food restrictions at home.
Number of "cross post" letters etc., *i.e.*, from one part of the field to another, weekly ..	Official, 1,400,000 Private, 2,800,000	
Postal orders sold weekly ..	81,000 (value £56,000)	
Postal orders cashed weekly ..	46,000 (value £12,600)	
Number of private telegrams delivered by post weekly ..	1,260	

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Number of private letter-telegrams despatched weekly ..	1,050
Number of registered letters from England weekly ..	175,000
Number of railway trucks of mails despatched daily from bases	100
Number of motor lorries used daily	240
Highest number of War Savings Certificates sold in one week.	32,726

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SOME BOOKS ON THE WAR.

By BRIG.-GENERAL J. E. EDMONDS, C.B., C.M.G., in Charge of Historical Section (Military Branch), Committee of Imperial Defence.

OF books on the War there is literally no end. In the Library of the Imperial War Museum, collected by the care of Professor Oman and its Librarian, Mr. Steveking, there were recently over 13,000; and every week brings more. It would require a well staffed intelligence department to examine them all. Any suggestions as to which are the best to recommend to officers who wish to learn something about the war as a whole must therefore be eclectic. The *Literary Supplement of the Times* is making a speciality of reviewing one or more books on the war each week, and it is worth while spending 2d. on it and cutting these reviews out, for future reference when winter essays and lectures come round again.

First and foremost of English books one must put Major-General Sir F. Maurice's *The First Forty Days*. It is a clear account of the German plans and the opening operations. Against it is its high price, 9s. Then there is Major Becke's *The Royal Regiment of Artillery at Le Cateau* (R.A. Institution, 7s. 6d.), which gives an excellent summary based on official documents of the most discussed of the early fights. As no German account of it has been permitted to appear, it is fair to assume that it was a great British victory. Lord French's *1914* has been exceedingly adversely reviewed by the Hon. J. W. Fortescue, the Historian of the British Army, in the *Observer*. He condemns it "as remarkable for its many omissions as for its obvious contradictions and mis-statements." The Field Marshal was, of course, dependent on his staff for his facts, as Charles II. was on his ministers for his acts; at any rate as a record of personal feelings and impressions of men and things the book is of great interest. The price is, however, a guinea.

The German General Staff have issued an official account of the First Battle of Ypres: *Die Schlacht an der Yser und bei Ypres* (Stalling, Oldenburg, 3s.), which is of extraordinary and absorbing interest, as it gives the German intentions, summaries of orders, orders of battle, etc., so that a complete picture of the immensity of the enemy's effort to reach Calais is presented. Unconsciously it is one of the highest tributes to the bravery and efficiency of the Old British Army, as it credits it with perfect entrenchments, countless

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machine guns, deadly accurate artillery fire, and numerical superiority. A translation of the book is shortly to be published by Messrs. Constable and Co.

The advance notices of Sir Julian Corbett's first volume of the official *Naval History of the War* up to and including the battle of the Falklands have appeared in the Press, and it is expected that it will be available in the autumn. I have had the privilege of reading it in proof. Apart from the interest of the subject, and the way it is treated, the book will do more to make army officers understand the *rôle* of the Navy in war than any other yet written; and they will realize how much the Navy did to get the Army and its supplies safely to the places where they were required.

Admiral Lord Jellicoe's book is rather for naval experts and statesmen than for the military reader and its price 31s. 6d. is a consideration.

For the early part of the war one is bound to go to French and Belgian books. Of a large number read, apart from M. Gabriel Hanotaux's many volumed work, *Histoire illustrée de la Guerre*, and General Palat's authoritative book, the fourth volume of which still leaves the war on the left flank of the Allies at 25th August, three books stand out. They are (1) General Berthaut's *L'Erreur 1914* (4.50 francs). This gives an excellent account of the reasons for the opening strategy of the French, the possibilities open to the Germans, and generally the preliminaries and commencement of the campaign. (2). *Le Revers de* 1914 *et ses Causes* by Lieut.-Colonel Thomasson (4.50 francs). This besides giving an account of conditions in the French Army before the war, describes and discusses the operations which led to the French retirement in August 1914. (3). The Belgian official account:—*L'Action de L'Armée Belge: Periode de* 31*st Juillet au* 31*st Décembre*, 1914, published by Chapelot, Paris, price 1s. A clear sober statement of facts. It should be read in conjunction with *La Campagne de L'Armée Belge* (31st Juillet, 1914—1st Janvier, 1915) published by Bloud et Gay, Paris, price 1.50 francs, which adds flesh and blood to the skeleton of the official narrative, and provides a good deal of information about the sieges of Liège, Namur, and Antwerp. There are besides, two excellent little French accounts by Pierre Dauzet, both 2.50 francs, plus 30 per cent., each:—*De Liège à la Marne* and *La Bataille des Flandres*, which narrate the whole of the operations to the end of 1914. They are easy reading and generally accurate.

For the battle of the Marne there is also a good little book in French, price 2 francs, by Gustave Babin, with nine sketch maps, showing the approximate positions of the armies on each day; those of the French, but not the German, are accurate. The best account of the Marne, however, has been written by a Swiss General Staff Officer, Major Bircher, in *Die Schlachten an der Marne* (Berne.

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Haupt, 11s. 6d.), which has an excellent map giving the route of von Kluck's corps.

Of German books, besides the official account of Ypres, there is also one on the opening operations in Belgium entitled *Luttich—Namur* which has a detailed account of the initial deployment, with map, and of the sieges of the two fortresses. Of diaries and personal accounts there is no end, but few are of much value except the novelist Walther Bloem's *Vormarsch*, which presents a vivid picture of von Kluck's army from the time it left Germany until it reached the Aisne; and Hofprediger Vogel's 3,000 *Kilometer mit der Garde Kavalerie*, concerned with the doings of the Guard Cavalry Division from August, 1914, to March, 1915. Both these books are exceedingly well written and instructive.

The only one of Engineer interest yet seen is Biernatski's *Als Pionier in Frankreich*: the letters of a subaltern in a Field Company to his wife. He tells her freely about the bridges he builds, the wire entanglements he puts up and other details which must have been rather boring even to an affectionate German *Frau*.

For the diplomatic and political moves between the murder of the Archduke Franz Ferdinand and the commencement of war, there is Professor Oman's masterly summary entitled *The Outbreak of the War* (H.M. Stationery Office, 2s. 6d.).

The following are recommended for the general reader who is tired for the moment of mere military history:—

Belgium under the German Occupation, by Mr. Whitlock, the American Minister in Belgium (Heinemann, 25s.), a most striking story by a skilled writer; *Scenes from Italy's War*, by Garibaldi's historian, G. M. Trevelyan (Jack, 10s. 6d.); *The Last Million*, by Ian Hay, of the *First Hundred Thousand*, (Hodder and Stoughton, 6s. net), although written principally for an American public it is nearly as interesting as his first military book; and last but not least, *Les Silences du Colonel Bramble* (Paris. Grasset, 3.50 francs), an inimitable appreciation of the British officer by a French interpreter.

Some suggestions as regards books on the campaigns other than in France will be offered in a subsequent notice.

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THE RAISING AND REPAIR OF THE RAILWAY BRIDGE AT HOUPLINES.

By MAJOR E. M. SINAUER, R.E.

THIS work was carried out in 1915 by the 8th (Railway) Company, R.E.

General Description of Bridge and Damage done by the Enemy (see *Photo* No. 1).—The bridge carried a single line of railway (Armentières-Comines Line) over the river Lys at Houplines, just east of Armentières. It consisted of a single span, 125 ft. clear, the total weight being about 100 tons. It was blown up by the enemy on 15th October, 1914, being cut between the 4th and 5th panels. Both lower booms and the west top boom were entirely cut through, the east top boom being bent into a " V " at the lowest point. One cross girder, four rail-bearers and many braces were badly damaged. There were also many other holes in various members, repairable by patching. Both shore ends had slipped forward on the abutments, and the two pieces of the bridge were slewed 18 in. down stream.

Description of River at the Site.—The river Lys is canalized at this part of its course, with the tow-path on the left (north) bank. It marks the frontier here, the north bank being Belgian, and the south, French. The general cross-section is as follows :—

North Side :—There is a sharp fall to the deep channel, which has about 13 ft. of water, the bottom being hard.

South Side :—A mud bank projects out into the stream, ending suddenly in a very sharp fall to the channel ; the mud here is very soft and 5 to 6 ft. deep.

The contour of the firm ground under the mud is by no means parallel to that of the surface. The section is further complicated by the fact that, owing to the river making a bend, the deep channel runs diagonally and not along the axis of the river.

During the winter and early spring there is a considerable current, and, owing to the sluices lower down the river being in the possession of the enemy, heavy rains caused rapid floods. These floods considerably hampered the work in its early stages. In the late spring and summer the current is gentle, and the normal water level well maintained.

Military Situation.—The enemy trenches in front of Frelinghien were about 3,000 yards only from the site, and from them both ends of the bridge were plainly visible, though the centre was hidden

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from view by some small houses on the north bank. In view of this, the work was at first proceeded with very gingerly. Originally it was not intended to complete the work until the enemy had been pushed back, but only to raise both ends just clear of the water, so as to prepare the steel work for the new pieces. As, however, the enemy did not display overmuch interest in the proceedings, it was later on decided to complete the work.

Owing to the proximity of the enemy no trains could be run to the site. Material sent by rail had to be unloaded at Armentières Annexe Station, 1½ miles away. The bridge itself was only shelled twice during the progress of the work, and no damage was done. Owing to several of our batteries being in position near by, the neighbourhood was frequently shelled, but the casualties amounted only to two men slightly wounded.

General Scheme.—The general scheme for the work was to float out and sink sleeper cribs in the stream, and from these to jack up the two halves of the bridge. The damaged portions were then to be cut away and new pieces fitted in, thus effecting a permanent repair, and also clearing the waterway for navigation. The first lifting had to be done by baulks placed under the top booms, the cribs being on the outside of the girders. When the lower booms were sufficiently clear of the water, four new cribs were introduced under them, and the jacks applied directly under the girders. As the lower booms had been entirely submerged, the damage to these could not be seen until they had been raised clear of the water. When this had been done, the damage turned out to be of a greater extent than had been anticipated, necessitating new pieces of considerable length and weight.

Preliminary Work.—The east top boom was cut with gun cotton, thus leaving the two pieces of the bridge quite free. As many of the rails, sleepers, etc., as could be got at were removed. Dug-out shelters for the working party were prepared on the sheltered side of the railway embankment on both banks.

Anchorages.—Both shore ends were anchored back to prevent any tendency for the girders to slip off the abutments during raising. These anchorages consisted of buried logs, from which led several returns of 2-in. wire rope. Round the end of each girder was a stout chain, and this was connected to the wire rope by railway screw couplings, taken from damaged trucks. These couplings were used to take in the slack as the girders rose.

Design of the Cribs (see *Plan* No. III.).—Careful sections of the river were taken at the exact spots where it was proposed to place the cribs. The bottom of each crib was designed to fit the bed of the river. On the north side, where the bottom was hard, this worked very well, all four cribs settling only a few inches and remaining vertical. On the south side, on account of the depth of soft mud,

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great difficulty was experienced. Owing to the slope of the mud, a horizontal solid mud-floor would have caused the cribs to tilt badly. It was therefore decided to try and sink the cribs through the mud like caissons, until the hard underlying bottom was reached.

Of the first two cribs placed here, No. 4 gave no trouble. No. 3 assumed a truly alarming tilt towards the girder as soon as lifting commenced. It was found to be quite impossible to rectify this, except by starting all over again, but as this would have involved lowering the girder again, and even then there would have been no guarantee that the new crib would behave any better, it was decided to take the risk and carry on with it in this condition. The other two cribs on this side, Nos. 5 and 6, behaved fairly well at the start ; but when the girders were traversed to their proper axial alignment, they both started to tilt badly. It would appear that these cribs did not get right through the mud to the hard bottom, but, after sinking about 4 ft., attained a position of equilibrium for that particular loading. When the position of the loading was changed even slightly, as when traversing the girders, this equilibrium was disturbed and the cribs started to tilt.

However suitable cribs may be on a hard bottom or on level mud, their use in deep water, on a sloping mud bank, and with heavy loads, cannot be considered satisfactory. The uncertainty as to how they will behave under these conditions, and the impossibility of correcting any tilting, once started, leads to many difficulties and much anxiety.

Construction of the Cribs.—These were all built on the tow-path, to a height corresponding to the depth of water at the proposed position. The sleepers composing them were bored at the ends and threaded on to long bolts. They were ballasted so as to float just clear of the bottom when in position, and were then sunk by extra ballast being put in. The first two constructed had their initial ballast composed of gravel in sandbags, but it was found that, if the crib tilted when being floated out, the ballast shifted, thus upsetting the balance and causing trouble. The remaining cribs were therefore ballasted with short lengths of old rail, spiked on, which proved satisfactory.

Launching and placing the Cribs.—The launching ways consisted of two rails, the shore ends being fastened to the two horizontal rails upon which the crib was built, and the outer ends being spiked to a sleeper, which acted as a distance piece. The centre lines, and the up-stream and down-stream faces were marked on the cribs in white paint before launching. Corresponding marks were placed on the girders to show the exact positions of the cribs. Head ropes and foot ropes were attached for manœuvring the cribs into position. After launching, the crib was towed to its position, and then sunk until it rested on the bottom by putting in extra ballast.

Lifting Baulks.—For the first stage of raising, baulks under the top

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boom were used. For the short (north) end of the girder one 10 in. × 20 in. × 30 ft. was employed, and for the long (south) end two 10 in. × 20 in. × 40 ft. bolted together. To assist in keeping the baulk vertical as the girder rose, semi-circular saddles of wood, sheathed with iron plate, were placed on the baulk where it came in contact with the upper boom. To take the heads of the jacks, oak blocks were used.

Jacks.—The jacks available were four 40-ton hydraulic non-traversing, two 30-ton hydraulic traversing, and six 15-ton screw traversing. The hydraulic jacks were by no means new and gave a lot of trouble. The 40-tonners had too small a base and tended to tilt unpleasantly at the slightest opportunity.

The normal procedure was that the hydraulic jacks did the raising, the screw jacks following up closely the whole time. When the hydraulics were up to their full travel, an extra turn was given to the screw jacks to get them tight up, and these latter then carried out the *rôle* usually filled by wood packing. The great advantage of this was that none of the height gained was lost when changing the jacks for a fresh lift, as is always the case with timber packing. As an additional precaution, the lift was also followed up with emergency timber packing.

As speed was no object, safety was a primary consideration, and it was found to be advisable to change the jacks for a new lift on only one crib at a time. Changing them on both sides simultaneously tended to set up movements in the girders and cribs which might have got beyond control. The question of supervision also affected the speed. Owing to the great liability of the 40-ton hydraulics to tilt, and to the unreliability of the cribs themselves, it was considered necessary to have every operation personally supervised by an officer.

As regards the arrangement of the sleepers on the crib to form the jacking floors, although by calculation the sleepers under the load would safely stand over the small clear span, it was found advisable to have several layers solid directly under the jack, as otherwise a considerable portion of the lift was lost through compression and flexion of the sleepers.

Raising.—First Stage (see *Plan* No. I. and *Photo* No. 2).—This went on steadily, the north end first and then the south, until the bottom booms were clear enough for the second series of cribs to be placed into position. As the submerged damaged parts came into view they were examined and the new pieces designed and ordered.

Raising—Second Stage (see *Plan* No. II. and *Photo* No. 3).—The new cribs having been placed under the lower booms, the load was transferred to them, and the lifting baulks removed. The old cribs were partly stripped and left in position as a stand-by, and for construction purposes. For the heads of the jacks a series of oak wedges, cut from old French sleepers, were made. Each set had a smaller

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angle than the preceding one, to allow for the flatter slope of the girder as it rose. The upper surfaces were recessed for the rivet heads, which otherwise tended to split the wood.

The two ends were taken up as high as shown on *Plan* No. II. and *Photo* No. 4. At this time, owing to the military situation, it was not proposed to continue any further for the present. The two ends were traversed up stream into alignment. This led to the tilting of cribs 6 and 7 mentioned earlier. The two ends were then left on good packing, and the jacks removed.

Cutting and Stripping.—As soon as the designs for the new pieces were got out, the ends of the old girders were cut and stripped. This went on at the same time as the raising. It had all to be done by hand, no pneumatic plant being available. This cutting and stripping left the last cross girder of the south end unsupported. This was therefore suspended from a baulk placed across the top booms, by two 2-inch wire cables, windlassed taut.

Arrival of the New Pieces.—These arrived in two consignments. The weights of the heaviest pieces were approximately :—

East top boom	...	...	2 tons.
West ,, ,,	...	...	3½ ,,
East lower boom	...	...	4½ ,,
West ,, ,,	...	...	4½ ,,

The first consignment, consisting of the top booms only, were put on two plate-layers' trolleys, and pushed by hand to the site. Trouble was caused by the trolleys being narrow in gauge, and frequently falling between the rails. The second consignment consisting of the remaining pieces, arrived about seven days later. In view of the previous trouble with the trolleys, it was decided to push the large bogie wagon itself round to Houplines by hand. This had to be done at night, owing to most of the line being under hostile observation. All the new pieces were lowered down to the river bank and arranged in order on ways. All the new pieces arrived painted with bright red lead, and were therefore camouflaged with paint to render them less conspicuous.

Size of Rivet Holes.—On the arrival of the new parts it was found that there was a discrepancy in the size of the rivet holes. The new parts had 23 mm. holes for 22 mm. rivets, whereas the holes in the old girder were only 22 mm. This involved reamering out all the holes in the old girders, a very considerable number. This had all to be done by hand.

Final Raising.—It was now decided to risk it and complete the bridge. The final raising was quickly done, and the ends were traversed back on to the abutments so that the gap was four inches longer than the new boom pieces.

Hoisting and Placing New Parts (see *Plan* No. IV. and *Photo*

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No. 5).—As the erection of a gantry might have attracted undesirable attention, it was necessary to devise a means of hoisting and placing the new pieces which did not project much above the top of the bridge. The arrangement used is shown on the plan. It was so designed that only materials already available on the spot were required.

The booms were the only pieces presenting any difficulty. The general procedure was that the piece was placed on a small barge floated out under its position, and picked up by the tackle. Whilst being raised it was manœuvred horizontally to clear the girders, and slid into position. The west top boom gave some trouble owing to the joints at one end being interleaved. One end was service bolted, and the gap mentioned before was then closed up by pushing the short end of the girder forward by means of horizontal jacks on the abutment. The other end was then also service bolted. The cutting and stripping, which was all done from the plans before the arrival of the new pieces, turned out to be quite satisfactory, all the new joints being good. A good deal of drilling, all by hand, had to be carried out for the cover plates and bracing. Nearly 3,000 rivets, mostly 22 mm. ($\frac{7}{8}$ in.) were placed, a very large proportion being in awkward places.

As much camber as possible was obtained by forcing up the centre of the bridge by means of the jacks on the cribs, before rivetting. These jacks were left in place until the rivetting was completed. When they were removed the camber was well retained.

Other Work.—After the rivetting had been completed the entire bridge was traversed 6 inches from the south to north, having been unequally on the two abutments.

New rails and sleepers were laid across the bridge. Cribs 1, 2, 3, and 4 were removed; some of the ballast was taken out from them and they were then towed to the bank, pulled out and dismantled. Cribs 5, 6, 7, and 8 were left *in situ*, with some packing under the lower boom, with a view to minimizing the result of possible damage by shell fire (see *Photo* No. 6). Later on they were removed altogether.

In order to strengthen the bridge, which had not been designed for the heaviest type of locomotives, supports were put under the second panel point at each end. These supports were not meant to replace the abutments, but only to take a portion of the load. The old bridge possessed no sway-bracing and some was therefore fitted.

Owing to the military situation, it was not possible to test the work under load.

Time Taken.—The job was commenced on 3rd February, 1915, and completed on 3rd July, 1915. It is to be noted that, owing to the special circumstances, work was not carried on at high pressure. At this early stage of the War, very little railway work was being

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THE RAISING AND REPAIR OF THE RAILWAY BRIDGE AT HOUPLINES.

Photo No. 1.

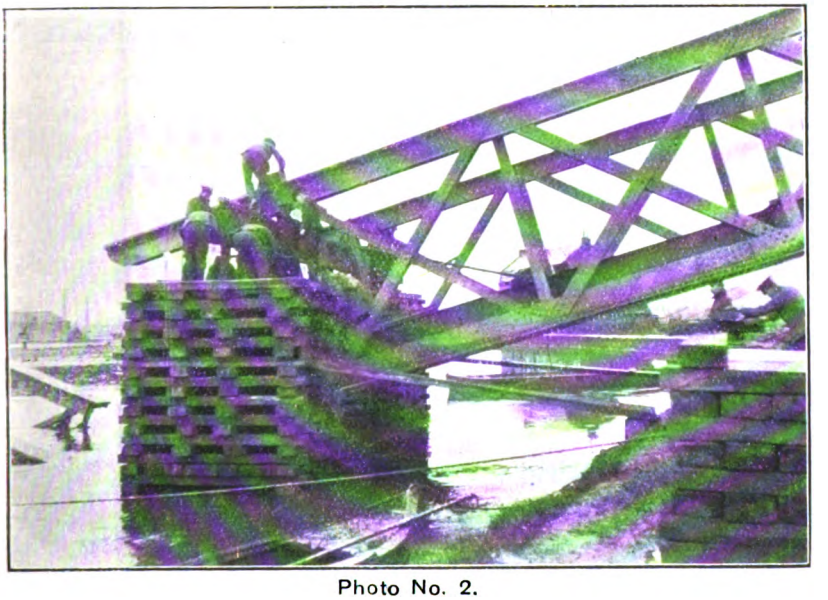

Photo No. 2.

Photo No. 3.

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THE RAISING AND REPAIR OF THE RAILWAY BRIDGE AT HOUPLINES.

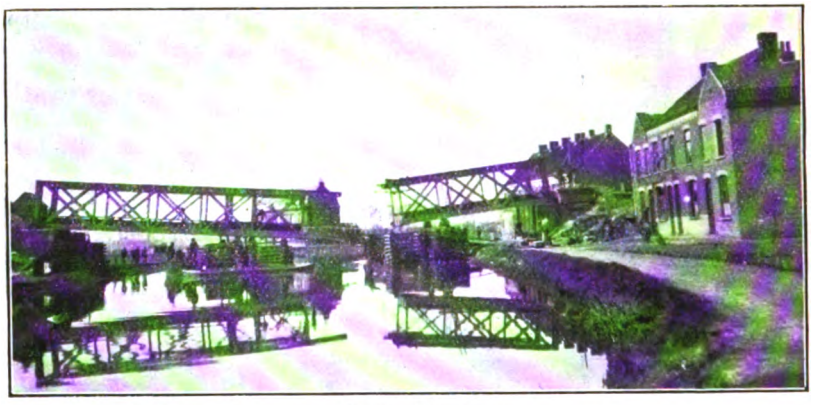

Photo No. 4.

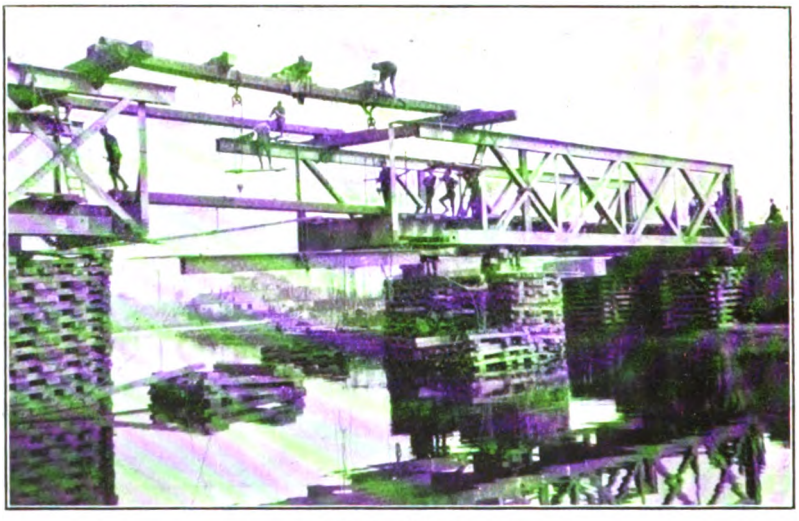

Photo No. 5.

Photo No. 6.

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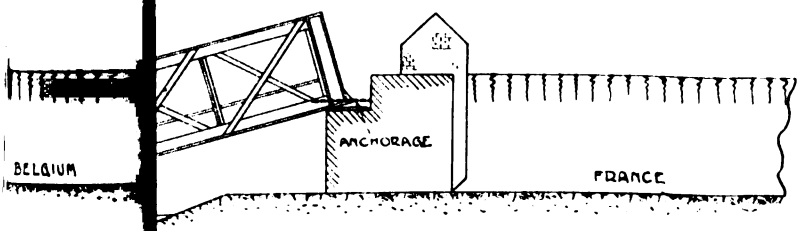
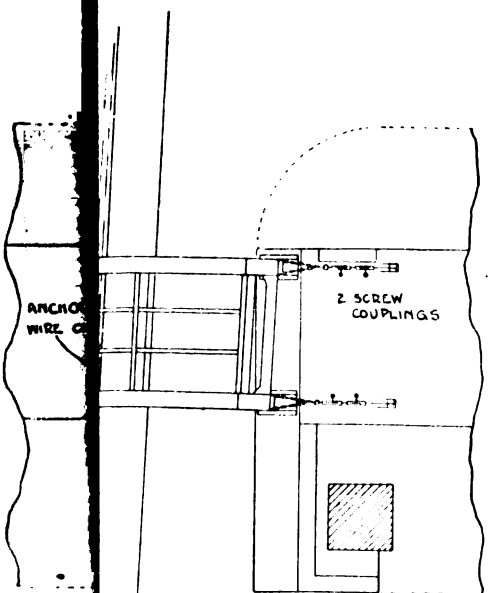
PLAN Nº I.



SKETCH OF BRIDGE AFTER DEMOLITION BY GERMANS



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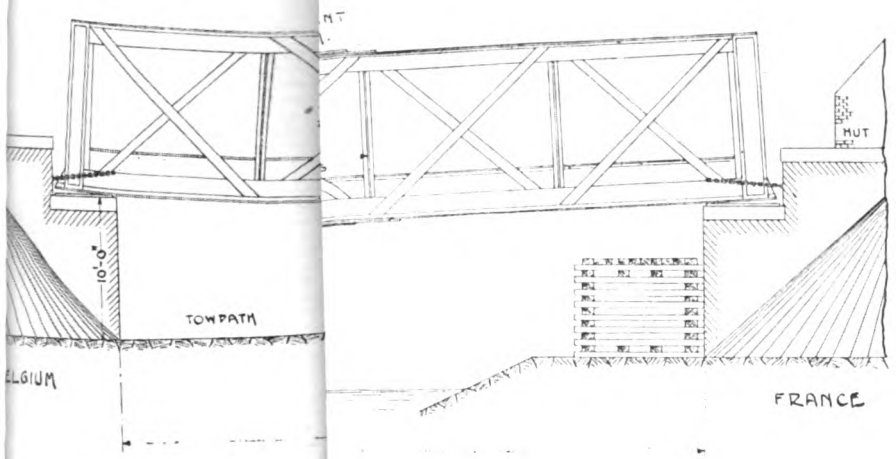
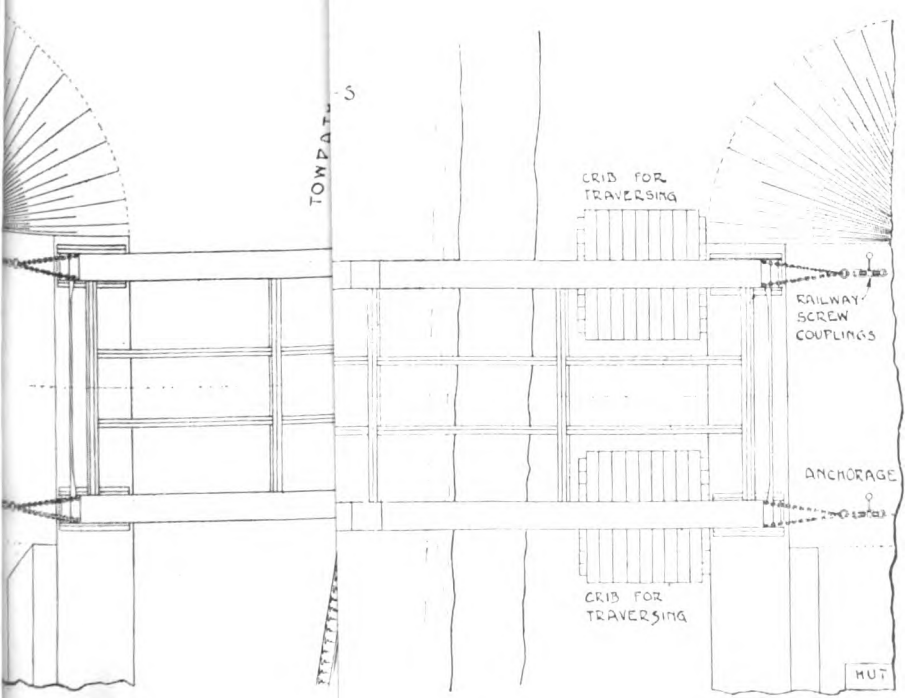
PLAN Nº II.





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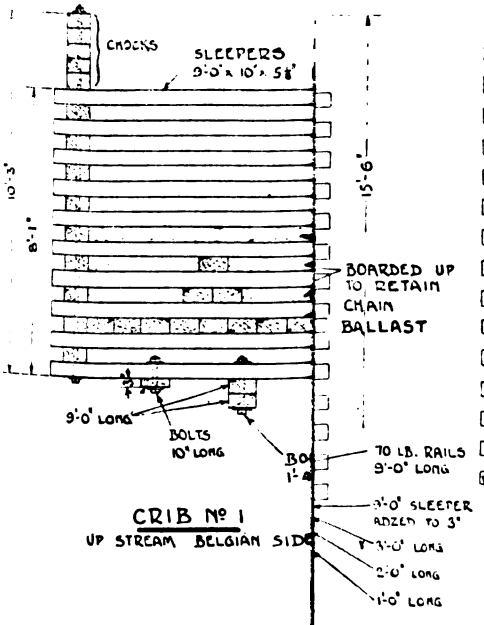
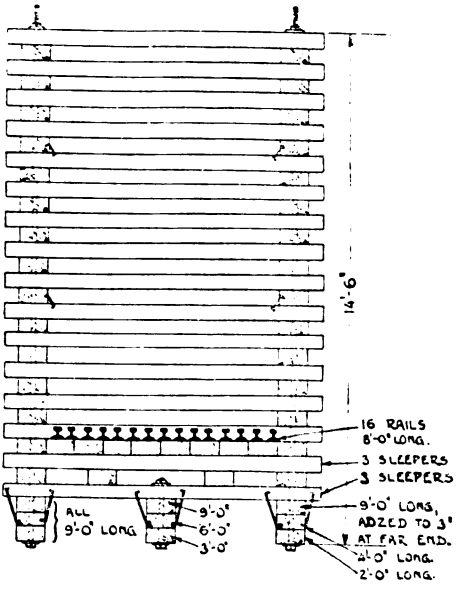
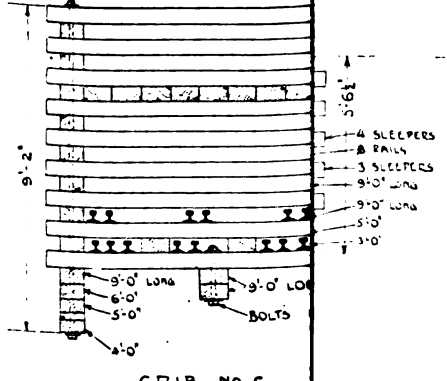
PLAN Nº III.



CRIB Nº 1
UP STREAM BELGIAN SIDE



CRIB Nº 4
DOWN STREAM FRENCH SIDE



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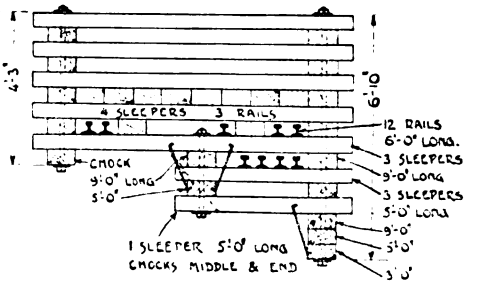
UP STREAM FRENCH SIDE



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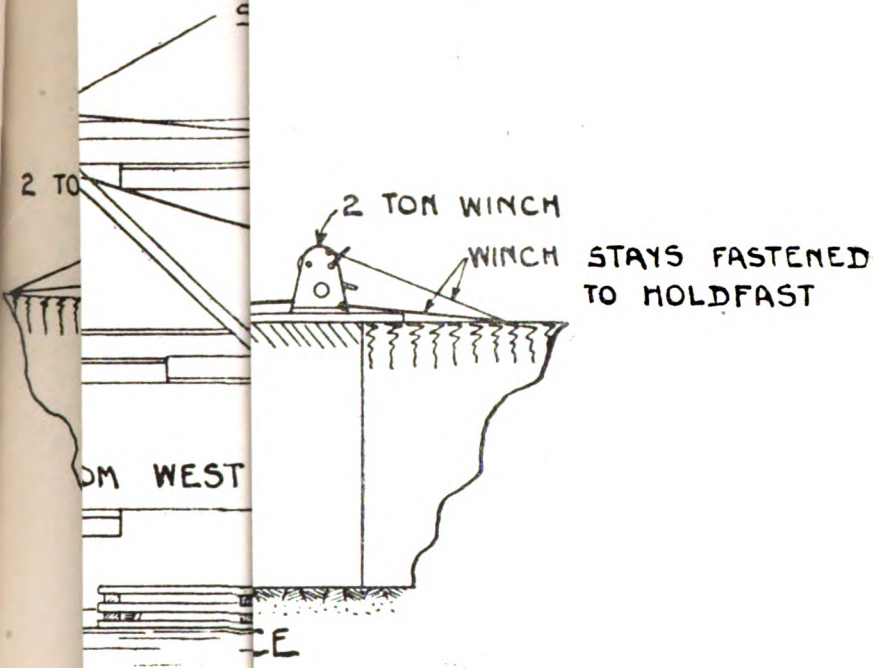
PLAN Nº IV.



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done by the British Railway Companies, R.E., and the detachment of the 8th Co., R.E., employed on this job, was therefore not required for work elsewhere. It was always understood that, should any advance take place, the work could be hastened and completed quickly. About a month in the middle was spent in marking time, before it was finally decided to carry on and complete the job. Again, towards the end, 16 days were wasted in waiting for the sway-bracing, which was late in delivery. The actual working days were therefore about 90. In view of the special conditions under which the work was carried out, the time taken is no real criterion of how long such a job would take if really pushed, and not so close up to the enemy.

Strength of Party.—The average strength of the party was as follows :—

3rd February, 1915, to 22nd May, 1915...	...	60 men.
23rd May, 1915, to 3rd July, 1915 ...	...	35 men.

All these were sappers, and no unskilled labour was employed in addition. It is doubtful whether a larger party could have been usefully employed, except by working in several shifts ; but in this particular case speed was no object, and in any case flares for night work would not have been permissible.

With regard to officers, for the first month-and-a-half the equivalent of only 1½ officers were available. For the next month two officers were on the job, and for the last three months only one. In a job of this kind, where a great amount of personal supervision is required, at least two officers should be available for the work.

Later History of the Bridge.—The position of the front line in this neighbourhood did not move until April, 1918, and so the repaired bridge was never used. When the Germans then advanced, the bridge was again blown up and only a few tangled bits of steel work are all that now remain.

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CORRESPONDENCE.

TRANSPORT FOR R.E. FIELD UNITS.

To the Editor, R.E. JOURNAL.

SIR,

May I be allowed the space to make a comment on Capt. Pennycuick's letter in the June *R.E. Journal*, in which he recommends the use of a "motor-tractor of the tank type" to draw the transport of R.E. field units.

The principle would appear sound enough for trench warfare; but it must be recollected that this is only a temporary phase and that armies cannot afford to give up their mobility. During a rapid advance, as has been proved last year in France, field troops depend almost entirely on pontoon bridges. It is obvious therefore that an R.E. field unit must be able to cross such a bridge.

This surely is the root of the whole matter. Until field companies carry equipment capable of taking motor-tractors of tank type, they cannot be equipped with such a form of transport. The present heavy pontoon bridge, as erected in 2nd Army Area in 1918, would absorb the whole existing equipment of the divisional R.E., not to mention the extra parts, joists, etc., for one gap, and is therefore out of the question. Probably an entirely new design of field bridge would be required before this alteration in transport could be made.

Yours faithfully,

J. B. GLUBB, *Lieut., R.E.*

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Col. E. C. Seaman, C.B., C.M.G., R.E.

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MEMOIR.

COLONEL E. C. SEAMAN, C.B., C.M.G.

EDWIN CHARLES SEAMAN was born November 4th, 1867—the third son of the late E. C. Seaman. He was educated at Melcombe Regis School where he distinguished himself in mathematics, and entered Woolwich in 1884—passing out 3rd in the list commissioned February 17th, 1886, after gaining the prize for mathematics.

In 1890 he was appointed Assistant Instructor in Submarine mining at Chatham, especially for Brennan Torpedo duty, at which he remained until 1897, during which period nearly the whole of the R.E. *personnel* officers and men who were initiated into those mysteries passed through his hands. He was an enthusiastic and untiring master of that peculiar weapon and was of the greatest value in developing the improvements that were from time to time introduced, until the abolition of submarine mining and the development of the submarine put an end to its use.

After a tour of service in Malta in command of the 28th Company, where he left his mark as the man who, though at all times up to his eyes in work of one description or another, was always ready to take on any outside and unpopular job, such as Secretary of the then enormous R.A. and R.E. Castile Mess, he returned to Chatham in 1902 as Superintendent of the Brennan Torpedo factory until it was closed in 1903.

Another tour of service followed in Malta, with which Island he had formed ties by his marriage with Miss B. Parnis in 1901. He served there till 1908 as Staff Officer to the Chief Engineer.

In 1908 he was selected for the appointment of Inspector of Electric Lights at the War Office, which he held till 1912. During this period the development of Coast Defence Electric Lighting which had arisen out of the abolition of the Submarine Mine Defence and the consequent demands for increased artillery defences, was at a maximum especially in the colonies. Seaman's clear common sense, and infinite capacity for work, again eased the paths of all those concerned in these matters.

Another tour of duty in Malta succeeded in 1912 as C.R.E. until the beginning of the war, when Seaman assumed the duties of Chief Engineer. The following extracts from a letter from Major-General Sir G. K. Scott-Moncrieff bear witness to the

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invaluable work done in Malta and up to the date of his untimely death :—" I had known Seaman personally ever since he joined at Chatham in 1886 and I was Assistant Adjutant at the S.M.E., but I first came into touch with him professionally when he was C.R.E. of one of the districts in Malta, and I was inspecting the works in the Mediterranean early in 1914. There was a big scheme under consideration for re-modelling all the important works in that island, and he visited with me, and explained to me on the spot, the various details of what was proposed, at Burghiza, Leonardo, Ricasoli, and other works at the S.E. end of the island. I was very much impressed with the breadth and soundness of his views, and the thorough grasp he had, not only of the principles of defence, but the constructive details of the work. More than this, he had a most comprehensive knowledge of questions of accommodation. The old works at Vittorioso, Cottonera, and Ricasoli had been constructed in mediæval times and the re-modelling of these to suit modern requirements was a task involving much engineering knowledge and ingenuity. He had it all at his fingers' ends, and I was most favourably impressed with all his proposals and with the careful accuracy with which he had balanced the means at his disposal with the aims in view. I was also much interested to hear from him how, the previous year, he had been in charge of the works necessary for our temporary occupation of Scutari in Albania, and the knowledge he had there acquired of local conditions. It was on account of this experience that I arranged in the autumn of 1915 for him to go to that part of the world again, on reconnaissance. After the outbreak of the war, the Chief Engineer (Colonel Horniblow) was recalled from Malta, and Seaman took over his duties. These were very heavy, involving the construction of many temporary buildings, as well as the completion of fortification schemes. From personal correspondence which I had with the Governor (Lord Methuen) I learnt how admirably he carried out these duties, as I had indeed expected. In the month of October, 1915, it was decided by the Cabinet to send assistance to the Serbians, who were then hard pressed, by making a road through the Montenegrin mountains. This decision really came far too late in the day to be efficacious, but as soon as I heard of it, I cabled to Lord Methuen to detail Seaman to go at once to Medua, reconnoitre the route, and send a report to the officer (Colonel Macdonald, D.S.O.) who had been entrusted with the task, and who would meet Seaman either at Rome, or on the spot. Seaman started at once, and by dint of travelling without any baggage managed to reach Albania and make a reconnaissance. His personal belongings were, I think, following him in a small steamer which was torpedoed by the Austrians. He had the greatest difficulty in getting back, finding his way by circuitous routes and with great hardship. The news he brought was I believe of the greatest value to Colonel

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Macdonald. He then returned to Malta, but not long afterwards I recommended his transfer home, to be a liaison officer between the Signal Service in the field, and the War Office. This was due to the desire on the part of the G.S. to have a closer touch between the vitally important needs of the Signal Staff in the field, and the War Office branch dealing with signalling equipment of all sorts, especially in connection with wireless work in aeroplanes. After he took up these new duties there was a very distinct advance. We had established at home an experimental W/T Station at Woolwich, and a W/T air station at Biggin Hill, but there seemed to be a missing link between these and the work in the field, which Seaman with his sound knowledge of the subject, his tact and common sense, was able to supply. Whether he was the actual author of the improvements in wireless telephony between aeroplanes I cannot now say, but it was from him that I learned, at Biggin Hill, of the wonderful progress that had been achieved. Most probably the foundations of this success were well and truly laid by Bagnold and Dumaresq, and their able band of assistants, and it was in continuation of their work that he brought matters to completion. When Dumaresq's lamented sudden death left the electrical branch of the D.F.W.'s department without a head, Seaman had brought the co-operation between the War Office base and the work in the field, to such a successful position that I felt he might well transfer his great ability to the vacant post. He had then to face a great expansion of the work. The demands for new signalling equipment, both on land and in the air, were growing enormously, and it became more and more evident that we must assume new responsibilities for supply. While obtaining all the assistance we could from civil sources, it was clear that these must be supplemented by our own efforts. Factories were established under our own supervision for the construction of telephones, and of wireless sets. No fewer than five of these were in full swing when I left the War Office, and in them a regular supply of field telephones, of wireless transmitters and receivers were made up and dispatched to the theatres of war. In addition, there were numerous demands for electrical apparatus for various places, not connected with signalling, *e.g.* the apparatus for electric power at Basra, and the equipment for electric light, etc. at the Egyptian aerodromes. In addition to this, the inspection of R.E. stores at Woolwich had grown into a gigantic organization, and the demands for anti-aircraft searchlights demanded new experiments and manufacture. The work he did was always characterized by the same thorough grasp of principles, and sound practical common sense. His personal tact and courtesy were as marked as his professional ability, and the smooth working of the great organization, and its marvellous economy is largely due to the individual qualities of the man, as well as to the scientific talent he possessed. Indeed I have often thought that the very success of the

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work and the absence of friction must have tended to obscure the enormous difficulties involved. It was with the utmost sorrow I heard that he, like Dumaresq—another admirable officer, had died suddenly. There is no doubt that both men gave their lives as really in the country's service as those who fell at the front, and in both cases we have lost men of the highest character, who sought their reward, not in rank or ribbons, but in the consciousness of duty done and in the devotion of their scientific talents to the great cause for which the nation was at war."

The following is a letter from Field-Marshal Lord Methuen, Governor and Commander-in-Chief, Malta, to the Secretary, War Office, dated Malta, 10th August, 1916:—

Sir,—I have the honour to acknowledge your telegram Number 11371 A.G.4.a. of the 8th August, 1916.

It is with deep regret that I lose the services of Lieut.-Colonel E. C. Seaman, Royal Engineers. Without his help I should not have been able to carry out the work required for the formation of the hospitals, and convalescent camps, which from 370 beds will in a short time expand to 27,000 beds.

Not only has he never made a difficulty, however impossible the nature of the site for a hospital camp might appear, but the work was always complete by the day he named, and at a comparatively small cost.

Few men would have had the courage to face the risks which the water supply presented for so large a number of patients. He gave me confidence from the first, and I cannot name any officer I have ever had under my command to whom I have been more grateful for good work done, quietly, accurately, and always with due regard to economy.

I have the honour to be,

Sir,

Your obedient servant,

(Sd.) METHUEN, *Field-Marshal,*
Governor and Commander-in-Chief, Malta.

Little remains to be said. In May, 1919, Seaman was selected for appointment once more to Malta as Chief Engineer, but a sudden attack of apoplexy, on May 9th, put an end to a life that had been devoted gladly and entirely to the service of the country.

The announcement of a well-earned C.B. in the Birthday Gazette appeared too late indeed for the recipient to enjoy the award, but to the greatest satisfaction of those who were aware of the invaluable services that it recognized. Previously to that Seaman had been awarded the C.M.G. for his services in Malta, and the Serbian order of the White Eagle with swords for his work in assisting the evacuation.

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REVIEWS.

REPORT OF THE CHIEF OF ENGINEERS, U.S. ARMY, TO THE SECRETARY OF WAR, 1918.

This report on the duties and operations of the Engineer Department, U.S. Army, for the year ending 30th June, 1918, enables one to form some idea of the expansion of the Corps during their first year of war. The original Corps of regulars consisted of a band, seven regiments and two mounted battalions, officered by 359 Engineer Regular Officers, whose normal duties in peace-time included a large amount of civil engineering work, especially in carrying out improvements to ports and river estuaries.

In this connection, the Chief writes :—" The excellent results which have been obtained since the war began by officers of the Corps of Engineers, in organization, supply and construction, both in the United States and France, must be attributed to the prior training such officers had received, and this training has been rendered possible to a very great extent by the action of Congress in placing under the charge of the Corps of Engineers, the river-and-harbour improvements and certain other civil work of the nation. Through such work opportunity has been given for the development of the Corps of Engineers in taking heavy responsibilities, in the habit of making weighty decisions, in meeting sudden emergencies, in the organization, operation, and care of large bodies of men, and in working with men not familiar with or subject to the discipline and regulations of military life. In addition, these civil works have given to the officers of the Corps of Engineers the practice necessary for any professional man, practice which could not be obtained in their ordinary military duties in times of peace. Experience has shown that the adopted practice of having a young engineer officer on entering the service spend his first two or three years in strictly military work and thereafter have tours of duty alternately in civil construction and in military work, keeps the officer fresh and interested in his work ; gives him a well-rounded mental and professional development ; and produces an engineer officer fitted for any service the war may demand."

The increments of temporary engineer officers and men required for war service were obtained in the following way :—

(1). *National Guard Engineers.*—These were organizations which were drafted from the various States into the Federal Service, and consisted of 17 Engineer Regiments, one for each of the 17 Divisions of the National Guard, with 605 officers.

(2). *Engineer Officers' Reserve Corps.*—These numbered by the end of the period under report 4,670 officers, who were obtained through the

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national engineering societies. An Engineer Enlisted Reserve Corps was also started but the men were subsequently transferred into the National Army.

(3). *Engineer Officers, National Army.*—In the autumn of 1917, as a restriction was placed on the number of out-standing commissions, and it became impossible to commission officers in the Reserve Corps and give them some instruction prior to the time they were actually needed for service, it became customary to commission the required officers for the National Army Engineer units, or in the Engineers, National Army. Up to the end of the fiscal year 4,386 such commissions had been issued.

National Army Engineer Troops.—The Engineer quota of a Division consisted of one Engineer regiment, and an Engineer train (1,695 men in all). The regiments had been previously termed " Pioneer " regiments but were now designated " Sapper," to avoid confusion with the newly-formed Pioneer Infantry regiments. Nineteen such divisional sapper regiments were formed and in addition five sapper battalions, one for each of the five corps Engineer regiments.

Special Engineer Troops.—At the beginning of the year 10 special regiments existed, including one forestry, five railway construction, three railway operating and one railway-shop regiment. The following additional regiments, etc., were organized during the period under review:

Forestry Regiment	1	Camouflage Regiment (only two companies as yet) ..	1
Auxiliary Forestry Battalions	3	General Construction Regiments	2
Railway Construction Regiments	2	Water Supply Regiment ..	1
Railway Operating Regiments	2	Mining Regiment	1
Railway Operating Battalions	14	Quarry Regiment	1
Railway Shop Regiment ..	1	Electrical and Mechanical Regiment	1
Railway Maintenance of Way Battalions	5	Crane Operating Battalion (only two companies as yet)	1
Railway Maintenance of Equipment Battalions ..	2	Surveying and Printing Battalion	1
Railway Transportation Battalions	2	Service Battalions	46
Railway Trades and Storekeepers Battalion	1	Motor Transportation Companies	18
Light Railway Construction Regiment	1	Pontoon Trains	5
Light Railway Operating and Shop Regiment	1	Army Pontoon Park	1
Railway Transportation Corps	1	Inland Watering Battalion ..	1
Supply and Shop Regiments..	2	(four companies)	1
Highway Regiment	1	Searchlight Regiment ..	1
		Gas and Flame Regiment ..	1

It is recorded that the 11th (Railway Construction) and the 12th and 14th (Railway operating) Battalions had already received commendations from the Allies for the parts they had taken in battle.

The Gas Defence Service.—An existing instructional Corps of 86 officers and about 200 men became an Engineer service of the National Army in March, 1918.

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The Tank Service was organized as an Engineer service, and by March, 1918, numbers stood at—officers 115 and enlisted men 1,050, when instructions were issued to organize it as a separate service.

Railway Transportation Corps National Army.—In October, 1917, after the arrival in France of some of the Railway units a railway transportation service was formed, and subsequently this organization became independent of other Engineer organizations. Altogether 238 additional officers for headquarters and general offices were commissioned in the Railway Transportation Corps, National Army, but the Engineer Department raised the *personnel* and purchased all their supplies and equipment.

At the end of the financial year the number of Engineer officers of all categories was 7,963, and the enlisted strength stood at 214,274, of whom approximately 130,000 had already embarked for foreign service.

The Training of Officers.—It was originally intended that all Engineer officers should receive instruction at Engineer Officers' Training Camps, of which three had been established in June, 1917, and at which the courses seem to have lasted about 10 or 12 weeks, but owing to the speeding up of the Army programme and to a considerable extent to the restrictions placed during the fiscal year on the issuance of reserve commissions, many officers were assigned to active service without any preliminary military training and several hundreds more with very little. In designing the courses of instruction at these camps no attempt was made to teach civil or other branches of engineering as such, as all officers had to be trained and qualified engineers before they could be commissioned. The first requisite in the training of modern armies is thoroughness and precision in fundamentals and details. The courses were designed to teach, as thoroughly as possible, the duties of an officer in the character of (*a*) Instructor, (*b*) Manager, and (*c*) Leader, and included (1) the fundamental training of an Infantry soldier, (2) practical experience in command, including the duties of corporal, serjeant, lieutenant and captain, (3) company administration, supply, and army paperwork generally, (4) applications of the principles of civil engineering to military conditions, especially practical instruction in reconnaissance, bridge-work, trench lay-out and construction, demolitions, etc., and (5) tactics, battle exercises, map problems, terrain exercises and problems in troop leading.

Enlisted Personnel. In the first rush of voluntary recruiting many suitable men were lost to the Engineers, and considerable difficulty was experienced later in obtaining the transfer of these men, who had already proved their value in other units. The sudden expansion of the establishment precluded much central control on the training, and commanding officers, who were at first all regulars, were left largely to themselves. But subsequent inspections showed that methods and results, although excellent as a rule, showed considerable lack of uniformity, and a more centralized control over such training was instituted by the Chief of Engineers. At the end of the period under review methods were being standardized and the raising of Engineer units was being concentrated in a few well-fitted localities. It was expected that by the draft and by voluntary enlistments a sufficient number of skilled mechanics would be obtained, but this was found not to be the case, and before

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the end of the period, schools had been arranged for the specialist training of about 1,000 selected men in 19 different trades, including railway operation and construction, pontooning, surveying, sound and flash ranging, mining, electrical work and oxy-acetaline welding.

The Chief of Engineers gives some interesting comments on the lessons of the war as applied to coast defence. Nothing has happened to throw any doubt on the truth of the principle that properly constructed sea-coast defences, properly manned and operated should successfully resist a naval attack. Mobile guns may be introduced, but fixed guns will yet remain necessary. Overhead cover must be strengthened to guard against plunging shots and air-craft bombing. The proposal that it would be better and more economical to emplace sea-coast guns in a much more simple way then has been the custom is not recommended. Of the total costs connected with sea-coast guns the *personnel* items are by far the largest. The additional amounts which must be expended in providing rapid ammunition service and in protection of the gun and *personnel*, must more than pay for themselves in the increased rapidity and accuracy of fire, in the increased protection of the gun carriages and *personnel*, and in a permissible reduction in the strength of the gun detachment.

F.E.G.S.

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THE YEAR BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY, 1919.

The Year Book of Wireless Telegraphy and Telephony for 1919 (pub. by "The Wireless Press, Ltd.") has recently made its appearance; it is the seventh annual number of this well-known publication, and like some of its recent predecessors the volume has had to be compiled under the hampering conditions of war and the restrictions imposed by the Censorship. Although these circumstances have prevented certain information on wireless matters becoming available to the public, nevertheless the volume well holds its own as the Guide Book on Wireless Telegraphy and Telephony.

The section devoted to Calendars has been amplified by the inclusion therein of a list of official holidays in various countries; this information will be found extremely useful to business men having commercial relations overseas.

"The Record of the Development of Wireless Telegraphy and Telephony" has been brought down to date. The year 1918 has been marked by no revolutionary changes in radio-telegraphy: the year's developments, however, show substantial steady progress. This progress is briefly reviewed under three main heads: (1) Improvements in Apparatus, (2) Extension of the Application of Radiography, and (3) Long Distance Communication.

It is pointed out under the first of the heads that the trend of progress towards continuous wave communication, as distinct from that by damped waves, has been specially marked. A particular impetus has been given to continuous wave communication by the continued development of the thermionic valve as an efficient receiver and generator of undamped oscillations. It is in the field of receiving wireless signals that the most remarkable progress has been revealed, a progress due almost entirely to the degree of perfection reached in the design and manufacture of thermionic valves. At the same time wireless telephony has progressed very considerably, particularly in the direction of reliability and increase of range; thanks also to the development of valve oscillations and receivers.

As regards the second of the above main heads, the extension of the application of radio-telegraphy has taken place chiefly in connection with the fitting up of installations on merchant ships; at the close of 1918 the number of vessels belonging to the British Mercantile Marine carrying wireless equipment had risen to between 2,500 and 3,000. One of the interesting events of the year was the opening of the powerful station at Balboa, at the Pacific entrance to the Panama Canal. The Chinese Government has also begun to concern itself actively with wireless telegraphy; during last year it let contracts to the Marconi Company for the supply of wireless telegraph and telephone sets and at the same time

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concluded a contract with the German Telefunken Co. for the construction of radio-telegraphic stations throughout the Republic.

Dealing with the third of the main heads attention is called to the fact that 1918 will go down in history as the first year to witness wireless communication over the greatest possible distance on this earth—from Europe to the Antipodes. On September 22nd two messages were transmitted from Carnarvon to Sydney, a distance of 12,000 miles. Earlier in the year—in March—wireless communication was established between San Diego, California and Pekin, a distance roughly of 7,500 miles. Several new high-power stations were opened during the year in the U.S.A.; one of them, i.e., that at Annapolis, Md., having, it is said, a range of at least 4,000 miles. The high-power stations at Croix d' Hins, near Bordeaux, and at Stavanger were also opened for traffic, whilst work was in progress, at the end of 1918, on important high-power stations at Buenos Ayres and Karlsborg, Sweden.

A certain amount of new matter appears in the section headed "National and International Wireless Laws and Regulations"; *inter alia*, geographical information relating to the Republics of Ecuador and of Honduras is given for the first time and the wireless telegraph situation in these countries is described; geographical information relating to Iceland, Malta, Mauritius and the Philippine Islands and the laws and regulations in relation to wireless telegraphy in force in these islands being similarly included.

The lists of Land and Ship Stations given in the section "Wireless Telegraph Stations of the World" occupy 250 pages. It has not been found possible, owing to the restrictions placed upon the publishers under the Defence of the Realm Act, to correct or bring these lists up to date. Some alterations, however, have been made in the information given last year. It is noticed that the ranges of a few of the stations have been increased; a few new stations have also been included in these lists.

A "Special Articles' Section" has been a feature of the *Year Book* since its birth; and the contributions from eminent men of science contained in the current issue are quite equal in interest and value to those which have appeared in previous numbers of this publication.

The first of the articles is entitled "Maxwell's Electro-magnetic Theory of Light," and is from the pen of Professor J. A. Fleming, F.R.S. The author reminds us that Maxwell's Electro-magnetic Theory of Light stands as one of the chief landmarks in the history of scientific thought. A brief survey is made of the work on the subject of light carried out by those who preceded Clerk Maxwell and the results of their discoveries are shortly stated. These results provided various arguments for and against the corpuscular and the undulatory theories of light. The true authorship of the undulatory theory of light, it is pointed out, must be ascribed to Robert Hooke, one of the founders of the Royal Society, and at one time its Secretary. Sir Isaac Newton was led to reject this theory, on the ground that an undulatory motion would spread round opaque objects just as sound waves do, and, therefore, that sharp shadows could not be formed. However, such *diffraction* does occur, but the amount of it depends upon the ratio of the length of the wave or undula-

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tion to the size of the object—this ratio is, generally speaking, very small. The extreme smallness of the light waves, viz., about $\frac{1}{50,000}$ of an inch, was not apprehended in Newton's time. Newton was also influenced by the phenomenon of the " polarization " of light, then recently discovered.

Further, the enunciators of the undulatory theory assumed that the vibrations of the æther must necessarily be longitudinal and hence there could be no asymmetry in the ray. These objections were subsequently met and overcome, when the tentative speculations of Hooke and his successors as regards the undulatory hypothesis of light were replaced by a scientific hypothesis resting on facts, as soon as the discoveries of Thomas Young and Augustin Fresnel came to the aid of research workers.

From their discovery of the phenomenon of *interference*, in connection with two streams of light proceeding from the same source but by two paths of different length, Fresnel and Young formulated the proposition that light vibrations were transverse or at right angles to the ray. This type of theory had, in the first quarter of the nineteenth century, been found to give a fairly good explanation of the facts of optics, although it created special difficulties of its own which led to the development of numerous æther theories.

Maxwell held that it was unphilosophical to fill space several times over with different hypothetical æthers in order to meet the theories of physicists in relation to electric, magnetic and light phenomena. He therefore presented to himself the problem of deducting from one æther both the optical and electro-magnetic phenomena. Moreover, he was convinced that all speculations as to the inner structure of the æther were likely to be very wide of the truth, and that even if we imagine a mechanism by which we can explain the facts of nature, it does not in the least follow that they are produced in that particular way.

Professor Fleming explains how Maxwell was led from the actual facts of experience based on Faraday's discovery of the creation of an induced E.M.F. in a loop of copper wire when a permanent magnet was moved towards it, to perceive that the same kind of action must take place when a magnet is brought up towards a circuit formed of an insulator, in place of a conductor, only that owing to the insulating quality, the E.M.F. induced could not produce an electric current, but only an electric strain or displacement.

Maxwell also stated a second important principle, viz.: that electrical displacement in an insulator or dielectric, *whilst it is changing*, is in effect an electric current, and must therefore produce around it magnetic force.

Maxwell gave mathematical expression to these two principles. The equations giving the relations of the forces and strains, magnetic and electric, and those formulating the two circuital laws are given by Professor Fleming in the original article, as also the well-known mathematical expressions $-mk\ddot{B}=Curl\ (Curl\ B)$, or $-mk\ddot{D}=Curl\ (Curl\ D)$, which are developed from them and represent a wave propagated in an incompressible material with a velocity $\frac{1}{\sqrt{mk}}$.

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In plain language these expressions mean that if an electric current is created in a wire the result is to form round the wire a magnetic force which theoretically extends out to infinity. If the current is supposed to be instantly reversed in direction the magnetic field would not be instantly reversed at all distances, but the reversal would take place at gradually increasing times at gradually increasing distances. That is to say, Maxwell's equations showed that magnetic flux or induction and electric strain or displacement are propagated through space with a velocity of $\frac{1}{\sqrt{mk}}$.

The value of the velocity $\frac{1}{\sqrt{mk}}$ has been found by an experiment, many times performed, to be nearly 300,000 kilometres per second: this is exactly the velocity of light. Consequently Maxwell's investigations led at once to the conclusion that electric and magnetic effects are propagated through space with the velocity of light.

"It was then impossible," Professor Fleming points out, "to avoid the conclusion that the optical and electro-magnetic æthers were one and the same. Also it seemed highly probable that what we call light, is merely an electro-magnetic wave, and that the transverse displacements which constitute that wave are electric and magnetic fluxes or strains."

It will be seen then that Maxwell's theory embraced in one single explanation all optical and electro-magnetic phenomena, and enabled a common origin to be ascribed to both. At the same time it opened up new fields for experimental investigation in which, as is pointed out in the original article, a rich harvest has already been reaped and gathered in.

The second article has been contributed by Dr. W. H. Eccles: it is entitled "Maps for Radiotelegraphy and Aeronautics." It is pointed out therein, that when electric waves from a high-power sending station pass over the surface of the globe, that portion of the energy which reaches a particular receiving station and operates the receiving apparatus, so far as we know, must have travelled from one point to the other along the shortest path; *i.e.*, along the great circle on which both these points are situated. It is sometimes of importance, and often of interest, to trace the path of the electric rays. This can readily be done on a terrestrial globe, but such globes are not always available.

Dr. Eccles points out that given suitable books of tables and the necessary leisure the great circle path can be calculated between any two points and marked on any kind of a map. However, a more convenient method of meeting the situation is that furnished by the plotting of special maps capable of showing great circles' courses as straight lines. Such maps, known as gnomonic projections, not being procurable in a form suitable for wireless students, Dr. Eccles describes, with the aid of diagrams, a simple method of constructing these maps and the scales to be used with them. A gnomonic map with Greenwich as origin accompanies the text of the original article.

The third article is entitled "The Methods and Progress of Radiotelephony"; its author is Mr. P. R. Coursey, B.Sc. The essential

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outline of all practical radio-telephone systems may, Mr. Coursey points out, be said to comprise the following parts :—

1. An oscillation generator or source of continuous or nearly continuous waves, for the transmitter.
2. A transmitting microphone, or means of modulating the transmitted energy.
3. A receiving apparatus.
4. An aerial and earth (a counterpoise) system for transmission and reception.
5. Means for relaying to and from existing land telephone lines.

Each of these chief features are dealt with in the original article.

1. *The Transmitter.* The essential qualification is that the transmitter shall be capable of producing a steady train of oscillations of frequency above the acoustic limit (*i.e.*, above, say, 30,000 cycles per second), and preferably still higher, so as to be suitable for efficient operation with aerials of ordinary dimensions. It is not essential that the waves should be continuous, so long as the frequencies of irregularities are above the limits of acoustic frequency range. To render the spark frequency inaudible it must exceed 20,000 per second ; this frequency has been attainable since the invention of the quenched spark gaps. The quenched spark gaps may be operated with either alternating current or direct current, and Mr. Coursey deals, in the original article, with the requirements in each of these cases.

It is pointed out that it is of course possible in the cases where alternating current is employed to use more than three phases, and so have a lower initial A.C. frequency, but for most purposes a three-phase supply best meets working conditions.

With a direct current supply, the sparking rate is determined solely by the constants of the supply circuits charging the main condensers and by the properties of the sparking gap itself. The sparking rate can, therefore, readily be given quite high values and it is possible thus to generate an almost continuous wave eminently suited for telephonic transmissions. In this connection mention is made by Mr. Coursey of the spark gaps of Chaffee, Yagi, Washington and Ditcham, which have been developed for comparatively small power out-puts—using D.C. supply voltage of 500 volts.

Attention is also called to the Marconi multi-disc discharger, by means of which a practically continuous wave can be set up ; the actual instant of sparking being controlled by means of an auxiliary trigger-device. This apparatus is specially suited for use with fairly high-power units.

Until quite recently the best known generator of continuous waves, such as are necessary for radio-telephony, has been the arc—the Poulsen and its modifications. The Colin-Jeance arc in acetylene and hydrogen, the Moretti arc in water vapour, the Dubilier and the Dwyer arcs in alcohol have given more or less successful results in practical telephone working. Ranges of several hundred miles have been obtained by their use.

Undoubtedly the most interesting generators of continuous waves for telephone work are the various forms of vacuum valves. One of the most striking developments in modern wireless work has been that of

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the three-electrode valve with its various modern forms, from the small receiving valves to the large high voltage transmitting valves.

The very valuable feature of valves is, as stated by Mr. Coursey, their simplicity in operation and the very great ease of control over the output. They are also extremely useful for simple amplifying work, both at the transmitter and the receiver, and in amplifying the modulations obtained from the transmitting microphones.

Attention is also called to the high-frequency alternators, which provide a means for generating continuous waves; the most notable examples of these alternators are the Alexanderson and the Goldschmidt machines.

2. *The Modulator.* Next to an efficient generator the modulator, or transmitting microphonic apparatus, is the most important part of an installation.

The problem of the transmitter is a very difficult one and is briefly discussed by Mr. Coursey, who mentions the chief methods being employed to provide a solution. Firstly, for low-power work the simplest arrangement is to use a variable-resistance type of microphone either directly in series with or coupled to the transmitting aerial circuit. The attempts to increase the power capacity of the variable-resistance type microphones led to the development of the various forms of liquid microphones—the most successful of these being Vanni's and Chambers'.

Secondly, a means may be employed for modulating the out-going wave by causing the voice to control the timing of the aerial circuit relative to the primary circuit, or to the frequency of the oscillation generator. The earlier forms of " condenser microphones " belong to this class, but have little practical value.

Alexanderson has introduced an improvement recently, namely, the " Magnetic Microphone," designed by him. In this case it is the inductance which is varied by the voice, and not the capacity of the instrument.

Vacuum valves and valve amplifiers constitute a third important class of modulators.

3. *Receiving Apparatus.* Most of the usual wireless telegraph receivers are available without alteration for wireless telephone work and this subject does not call for any special consideration.

The use of receiving amplifiers is an important adjunct for radio-telephone work, and for this purpose valve amplifiers are stated to be the most useful instrument.

The one great difficulty that arises when receiving amplification is resorted to is that of interference, principally owing to atmospherics.

4. *Aerial and Earth Systems.* The requirements for radio-telephony are precisely similar to those of radio-telegraphy and need much the same equipment as that customarily adopted for wireless telegraph stations.

5. *Relaying to and from Land Lines.* It will readily be evident that an extremely important feature of radio-telephony is the need of some form of repeater or relay to link the wireless apparatus to the land line telephone system.

Microphonic types of repeaters—such, for example, as Brown's tele-

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phone relays—and valve repeaters are available for this purpose: the latter being the simpler in use as they require less adjustment and attention than the former. Valve repeaters employed in this way may also serve the purpose of amplification as well—a matter which is most important where the received signals are weak.

The great problem still requiring satisfactory solution is that of duplex speech through these repeaters. The actual repeating process is comparatively simple: the difficulty lies in adapting it to comply with the conditions of both the wire and wireless telephone simultaneously.

The various fields of utility of radio-telephony are touched upon briefly in the original article, and it is stated that in America some extensive pioneer work has been already carried out by one or two railroad companies in connection with the application of radio-telephony to railway train communication.

The interesting announcement is made that "The range over which speech has been heard has already reached some 5,000 miles." This result was achieved with a large number of valve transmitters in parallel—a method which is at present too costly for such long range work on a commercial scale. The hope is expressed by Mr. Coursey that the return of peace conditions will allow research work to be again taken in hand and that the solution of the problems which are still outstanding will be the result.

The fourth article is entitled "On the Determination of the Electrical and Acoustic Characteristics of Telephone Receivers." Mr. Louis V. King, D.Sc., F.R.S.C., its author, points out that, since its invention in 1877, the telephone receiver as originally developed by Alexander Graham Bell has come into general use. With increasing ranges of transmission in telephony and radio-telephony in recent years more attention has been directed to the telephone receiver itself as a vital part of the receiving apparatus in its essential function as a detector of extremely small variations of electrical energy. The main features of the instrument in its present form are briefly discussed by Mr. King with a view to directing attention to points in the design of the receiver which require further investigation. The subject is treated mathematically under the headings: "Elementary Theory of the Telephone Receiver"; "Measurement of the Electrical Characteristics of Telephone Receivers"; "Note on the Precision Measurement of Frequency"; "Measurement of the Audibility Characteristics of Telephone Receivers"; and "On the Acoustic Out-put and Efficiency of Telephone Receivers." The original article is provided with a number of diagrams, and is of a nature which does not lend itself to reproduction in abstract form.

The conclusion arrived at by Mr. King is that the telephone receiver considered as a means for transforming electrical energy into acoustic out-put is an extremely inefficient instrument; the magnetic hysteresis losses being chiefly responsible for this.

The recent trend of radio-telegraphy in the matter of power economy and long-distance transmission has led to a demand for increased sensitiveness in the receiving apparatus. The introduction of current amplifiers of various types, giving magnifications reaching to a hundred-fold and more, has to some extent met these demands. However, the

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essential requirements of to-day can alone be satisfactorily met by marked improvements in the design and construction of telephone receivers leading to higher acoustic efficiencies. Mr. King has directed attention to some of the more important directions in which alterations are required in existing forms of telephone receivers and he urges that the subject should be further investigated.

The original article concludes with a useful list of works dealing with the subject.

The last article is contributed by Dr. N. W. McLachlan, D.Sc., Eng., and deals with "Some Radio-frequency Phenomena." In this article are discussed some of the phenomena which the electrical engineer meets with when dealing with alternating currents. Dr. McLachlan points out that in the transmission of power by low-frequency alternating currents of 50 periods per second, two sets of phenomena are present: (1) Transient phenomena—*e.g.*, the phenomena accompanying the sudden switching in of a transformer or a long transmission line; in such cases electrical oscillations similar to those met with in the oscillatory circuits employed in radio-telegraphy are set up. (2) The phenomena which occur when an alternating current of fixed root mean square value flows through the circuit.

When low-frequency currents were first used commercially, it was found that cables constructed for the transmission of direct currents were unsuitable for alternating current. This was due to the fact that the same wire offers greater resistance to the passage of an alternating current than to that of a direct current, owing to (*a*) increased resistance caused by skin effect, and (*b*) increased reactance, which depends on the product of frequency and inductance. The situation was met by the construction of cables in which the conductors consisted of a number of small-diameter strands, each of which was insulated and properly spaced.

Again, in the case of a wire carrying an alternating current of constant root mean square value, assumed to be sinusoidal in wave form, the voltage drop across its ends depends upon (1) the frequency of the current, and (2) the configuration of the circuit. There is another effect which becomes prominent at high frequencies, viz., the self-capacity of the wire: this depends on the configuration of the wire, and is greater for a loop than for a straight wire. It is the capacity current and not the actual value of the capacity which increases with the frequency. The capacity current I is obtained from the formula $I=\omega KE$, where $\omega=2\pi f$, K=capacity and E=voltage.

There are, Dr. McLachlan points out, two additional effects which are of importance at high frequencies when the length of the wire is great, as in transmission lines, viz.:—(*a*) mutual inductance between the wire and earthed bodies; and (*b*) capacity between the wire and earthed bodies. These effects are due respectively to the magnetic field caused by the current and to the fact that there is a difference of potential between the wire and earth. Mutual inductance reduces the inductive effect of the current, whilst capacity to earth increases the capacity current.

The effects of high frequency oscillations in coils and in condensers

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are described by Dr. McLachlan, and he points out that in the case of coils, radio-frequency effects are modified if the core is iron or even a non-magnetic conducting material. The effect of inserting an iron core in a coil carrying a high-frequency current (assumed constant in magnitude and wave-form with and without the iron) is to increase the voltage in the terminals, and, therefore, the voltage between consecutive turns. This causes an increase in the self-capacity current of the coil, the earth capacity current, and in the dielectric loss in the insulation on the wires. Further, the power factor of the coil is increased due to both the iron loss and the dielectric loss. Thus, what may be termed the equivalent resistance of the coil is increased.

Attention is called in the original article to the uses to which the ionic valve is being put: in conjunction with oscillatory circuits, it has proved to be an excellent means for obtaining a high frequency, undamped and almost sinusoidal current; it has been of service in experimental work and in radio-transmission from aircraft, where small power is needed; it has also been used as a detector and amplifier in wireless and in other work.

Dr. McLachlan, in conclusion, briefly outlines a medical application of radio-frequency currents. Direct currents or low-frequency currents, it is well known, cause violent contraction of the muscles and considerable pain when passed through the human body. On the other hand, high-frequency currents of the order of a million periods per second, are used, no sensation other than that of heat is caused, even when the current density is large. Such high-frequency currents are used in the treatment of certain diseases and is termed diathermy. The temperature of the body can be raised several degrees above its normal value of 98·4° F. by such currents. The heating of the tissues is probably due chiefly to dielectric hysteresis, although part may be due to conductivity.

Some important and valuable notes are contributed by Mr. I. Shoenberg on "Value Patents for 1918." These notes are followed by "Particulars of Wireless Telegraph Patents in 1918." In the introductory paragraphs relating to the latter subject, it is stated that the records of the Patent Office show the number of applications filed during 1918 to be 21,932, an increase upon those of the previous year of over 2,000 applications. The number of applications relating either directly or indirectly to "wireless," however, shows a small decrease, the total being but 148, as compared with 160 in 1917; of the "wireless" applications by far the most important place is occupied by "valve" inventions.

In the section devoted to "International Time and Weather Signals," a *résumé* is given of the world-wide programmes relating to "Time Signals." A brief account also appears under the heading "Meteorological Signals," of the part meteorologists have played during the war in connection with aviation, etc.

The volume concludes with the "Useful Data Section"; but it has been found impossible to continue the development and expansion of this section *within the covers of the Year Book*; in consequence, a separate volume entitled *Standard Tables and Equations in Radio-Telegraphy*, to some extent a supplement to the *Year Book*, has been published.

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The following information, *inter alia*, still appears in the *Year Book* :— Definitions of terms used in Wireless ; Dictionary of Technical Terms ; International Rules for the Use of Symbols representing Quantities in Mathematical Calculations ; Weights and Measures (British and Foreign) Specification of the Beaufort Scale ; foreign and colonial money ; particulars of the leading companies engaged in the commercial development of wireless telegraphy ; biographical notices of those prominently associated with wireless telegraphy ; literature of wireless telegraphy and telephony ; directory of Wireless Societies ; and Lloyd's List of Signal Stations.

The *Year Book* certainly deserves a place on the book-shelves of every reference library, public or private.

W. A. J. O'MEARA.

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NOTICES OF MAGAZINES.

THE MILITÄR-WOCHENBLATT.

The Militär-Wochenblatt is still appearing thrice weekly in the old style, with the gazette and everything else, except the long list of decorations bestowed by the Kaiser, as in the old days. The articles and advertisements are very significant and show that Germany's heart is unchanged. The principal contents of the June numbers are :—

No. 141.

A criticism of the Peace Conditions.—They are of course *unerfüllbar.*

Selbständige Wehrkammer.—Notice of a Society it is proposed to found independent of the War Ministry to defend the interests of the Armed Forces and keep alive Germany's warlike spirit ; no doubt this will include secret drilling and preparation for war.

Translation of Lord French's " 1914 ".—With the passages that will please the German public in italics.

Situation in Russia and Poland.

Among the *Regimental Notices* is a list of officers of Infantry Regiment No. 18 who were killed in action ; the total is 80.

No. 142.

The *Decision of the O.L.H. (Higher Command) for the Offensive in the West,* 1918.—A determination to end the war by force of arms, as nothing more could be expected of Germany's allies.

Contribution to the Reconstruction of the German Army.—A discourse on training by a major of the War Ministry.

Translation of Lord French's " 1914 " (continued).

Among the *Advertisements* is a call for officers for "Dohna's Free Corps" to operate against the Poles in Silesia.

Roll of Honour of the Field Artillery Regiment No. 9.—51 officers killed in action.

No. 143.

The German Armed Forces in the German Peace Counter-proposals.—A very violently-worded protest by an old Lieut-General.

The decision of the Higher Command for the Offensive in the West, 1918. (continued).—A very interesting article. It is stated that the attack towards Amiens was stopped because the effect of surprise had been lost and too many men would have to be expended in continuing it by force ; that the attack in the Lys theatre was stopped because in the water-logged, devastated, and muddy plain, artillery could not get forward quickly enough ; the infantry, not sure of its support, hesitated or remained in the captured Portuguese Camps, and priceless hours were lost. No reinforcements came from Germany to replace casualties.

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The Champagne theatre offered possibilities of surprise. When the attack at the Chemin des Dames succeeded, it was hoped to attack by surprise near Noyon, but it took 14 days to get the guns from the Chemin des Dames there and it failed. The object of the Marne and Champagne attack which was to capture Rheims also failed, and did not use up the French reserves as was expected. In July the numbers were 205 German Divisions against 170 French and English, 12 Belgian, and 20 Americans. If Germany resumed the pure defensive there was a good chance of losing the war. The effect on her allies had to be considered. She attacked on the Marne and failed from want of men who were denied to her by the Homeland.

Uniform and Equipment of the New Army.—Field grey is to be retained with various facings to distinguish arms:—Engineers, black with bright red piping as before; but all Infantry, white; Cavalry, golden-yellow; Artillery, bright red; Heavy Artillery, with golden-yellow piping. Rank will be shown by rings on the sleeves.

Roll of Honour of the 37th Fusilier Regiment.—91 officers killed.

No. 144.

Changes required in the Officers' Pension Laws.—There are apparently two rates applying to officers who retired before and after 1906. The recall of 'dug-outs' has caused anomalies.

The Enemy Situation in the Summer of 1918.—Combats the idea that the German Higher Command made miscalculations with regard to Marshal Foch's reserves and American assistance. It gives the German calculations of the British and French divisions available which seem correct, and shows that the number of American divisions was over-estimated up to February, 1918.

Roll of Honour of the 1st Guard Dragoons (formerly Queen Victoria of England's regiment).—19 officers killed.

No. 145.

Disbandment of the Old Army.—What remains of the Old Army is assimilated as regards regulations to the new *Reichswehr*. Volunteers for it are accepted to speed up demobilization.

The Circular letter of the Higher Command of 21st May, 1919.—Denies that the O.H.L. sent out a circular letter to find out whether the German people wished to continue the war rather than accept the peace terms.

Protest of the Reichswehr Brigade No. 3 (Lower Silesia) against a Disgraceful Peace.—The M.W.B. prints this with approving comments.

Correction to the English Report, "The Advance in Palestine and Syria."—Objects to the statement made in the work issued semi-officially in Palestine that Marshal Liman von Sanders fled from Nazareth before the British approach. Gives extracts from his war diary to show that he and his staff were actually surrounded in Nazareth, and fought their way out, the escort losing 1 officer and 42 men killed, 1 officer and 64 wounded, and about 10 officers with 250 men taken prisoners.

Roll of Honour of No. 13 Hussar Regiment.—21 officers, 31 N.C.O.'s and 202 men killed.

J. E. EDMONDS.

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RIVISTA DI ARTIGLIERIA E GENIO.

May, 1919.

Auditory Zones and Zones of Silence.

La Rivista is engaged in the consideration of certain interesting phenomena caused by detonation, as for example, the double report and the air waves produced by the bursting of projectiles.

The acoustic phenomena of the war do not only affect the combatants, they are also of interest in districts far from the field of battle, and they attract the attention of students of acoustic phenomena, such as volcanic eruptions, which up to the present time have not been fully explained, while four years of war have allowed of the continuous and systematic observations which are necessary in researches of a scientific character.

References are made to a series of communications to the Academy of Science of Paris, to Esclangon, Perot, Schaffers, Collignon, and a study of the subject published in the Professional Memoirs of the Corps of Engineers, United States Army, and other sources.

The first and most obvious question in regard to acoustics in war is this: What is the greatest distance at which one can hear the sound of artillery fire? The reply generally given before the war, and also repeated by Esclangon, was that the distance was very limited, not exceeding 20, or at the greatest, 30 km. But certain sound phenomena that are noted in some points of the earth of a similar character to those of artillery cannonading are still unexplainable. Such sounds are attributed by some to the incessant work happening in the interior of the earth, comprised under the general name of seismatic rumblings, and better known under special names in different places, Mist-puffers in Scotland, Mispoeffer on the Belgian coast, Neberlzerteller in the North Sea, Bramidos on the delta of the Ganges, etc.

It is a remarkable fact that these mysterious sounds happen only on the coasts during calm weather with a high temperature and with determined winds, and never under other conditions, circumstances especially strange for rumblings from the interior of the earth. Now, Bigourdan cites some examples to show that the fire of artillery can be heard at greater distances than those above quoted.

In the trials made in 1736 by the Academy of Science at Paris, between Montmartre and Monthery on one side and between Montmartre and Dampmartin on the other, the firing cf guns was heard at a distance of from 28 to 31 km. Such distances extended to 50 km. and more in the trials made in Italy by Bianconi in 1740. Four years after at Cayenne the fire of guns was heard at a distance of from 12 to 40 km. But the limits of the auditory zone can be extended to more than four times this distance, as full confidence may be placed in the statement that, in 1867, salvoes of artillery, fired at a great Naval Review at Spithead, were heard at distances varying from 170 to 180 km.

Bigourdan adds that we are not cognizant of the law under which the greatest distance of perception varies with the weight of the charge; he supposes that it may vary with the square of the weight of the charge, and he shows how, with heavy coast guns, it may extend from 200 to

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250 km. Others affirm that the calibre of the gun and the weight of the charge have not much influence on the auditory distance.

The acoustic phenomena in war are very complex, since in addition to the firing of artillery there is a second category of explosions caused by the air being violently affected by the passage of projectiles; and also a third, the explosion of projectiles and mines.

Esclangon maintains that in the cannonading in this war, at considerable distances from the front, it is not the sound of firing from the guns or mortars, or the bursting of the shells that strikes the ear, but only the sonorous waves (*andes de choc*) produced by the passage of the projectiles through the air.

It may be considered certain, according to Bigourdan, that the sound of cannonading has been heard in the present war at very considerable distances—some hundreds of kilometres.

In the first months of the war, Professor Van Everding, of the Utrecht University, noticed at Groninga, at 270 km. distance, the sounds of artillery fire from the forts of Antwerp, and with the development of the action, rumblings were heard at London, Caen, Mortain, Bagnoles de l'Orme, Blois, Bourges, Nevers, Baune, Verdun-sur-Doubes, Annecy, and Chamonix. Now, the shortest distances of such localities as Mortain or Bourges from the front are about 300 km.

From minute and precise observation made during the three years, 1915, 1916, and 1917, from Collignon, at 170 km. distance from the Arras front, from St. Quentin, and from Lassigny, and published in the *Comptes Rendus* by the Academy of Science at Paris, it was ascertained that the phenomena of sound at great distances are subject to laws of annual and daily periodicity. The favourable season for the transmission of sound is from May to September; in other months no rumblings were heard. In a period of three years there was only one exception to this law, from the 3rd to the 9th March, 1917, while in March, 1918, in spite of the most intense fire of the great German offensive, at Louviers the sound of cannon was only rarely heard. During the whole of the summer and autumn of 1916, the rumbling of cannon on the Somme was very intensive and persistent in Sussex. Now, in June and July of this year, the wind constantly blew from the west, and in August, September, and October, it seldom came from the east. In the winter and successive spring, exceptionally cold seasons, the sound of guns was not heard, even during the British offensive at Arras in April, 1917. In the summer, the sounds were again heard, less frequently than in 1916; but there was not a single instance when the wind was from the east. The sounds called Mispoeffers, heard on the Belgian coast, and of which a list was made, were only audible when the temperature was high.

E. T. THACKERAY.

(To be continued.)

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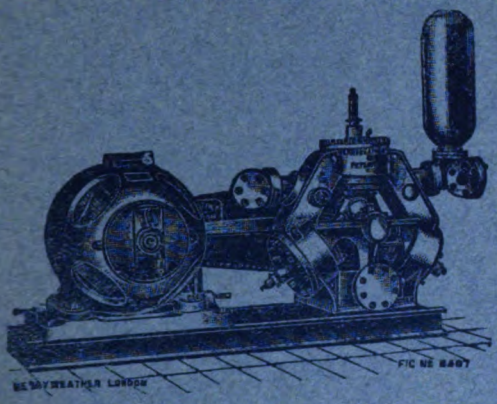

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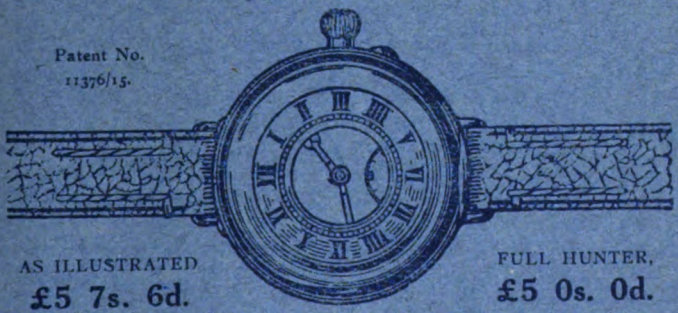

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OFFICERS OF THE SPECIAL RESERVE, TERRITORIAL FORCE, AND THE TEMPORARY LIST, ROYAL ENGINEERS AND MEMBERSHIP OF THE CORPS ASSOCIATIONS AND CLUBS.

PROCEEDINGS of Meeting of the R.E. Corps Committee held in Room 230, War Office, July 21st, 1919 (in accordance with the resolution agreed to at the Annual Corps Meeting on 14th June, 1919.)

The following were present:—Major-Generals Sir P. G. Twining, (D.F.W.), *S. H. Powell, (C.E., Forces in Great Britain), *L. Jones, (C.E., Eastern Command); Brig.-Generals T. A. H. Bigge, (A.A.G., R.E.), *A. L. Schreiber, (C.S.M.E.), *G. S. Cartwright, (C.E., Aldershot), A. W. Roper, (I.R.E.), *G. Walker, (C.E., London); Major L. Chenevix-Trench, (Hon. Sec., R.E. Corps Committee).

* Specially attended with power to vote in accordance with resolution dated 3rd July, 1919.

AGENDA.—To discuss Major-General Sir P. G. Twining's proposal:—

That in the opinion of this Committee it is not only desirable but is necessary that all possible steps be taken towards preserving the feeling of friendship and *cameraderie* which existed during the war between the Regular Corps of R.E. and the Special Reserve, Territorial, and Temporary Officers and Men, and that as a means to this end the R.E. Institute, and as far as possible other Corps Institutions, should be thrown open to these officers, and that steps be taken to bring this as far as possible to the notice of all such officers.

ACTA.—The opinions of the Presidents of the several R.E. Corps Institutions were read, and following conclusions reached:—

R.E. Widows' Society, R.E. Band Fund.—The Deed of Settlement in the one case and Army Orders in the other preclude the possibility of an extended Membership.

R.E. Institute.—Already accepts *all* R.E. Officers (including S.R., T.F., and T.C.).

R.E. Charitable Fund.—Already accepts *all* R.E. including S.R., T.F., and New Armies.

R.E. Games Fund.—Terms of admission to be considered by Games Committee.

R.E. Entertainment Fund, R.E. Dinner Club, R.E. Luncheon Club.—Officers of the T.F. and S.R. and Temporary Officers will be welcomed at the Annual Dinner and the Annual Evening Entertainment, and the Luncheon Club tent will be open to them.

R.E. Old Comrades' Association.—Already open to *all* Members of Corps of R.E. including S.R., T.F., and New Armies.

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2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie coat-of-arms in gilt on the cover and the Montgomerie book-plate with inscription inside. (*b*) The remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

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VISIT OF LORD KITCHENER TO THE GRAND FLEET AT SCAPA FLOW.

Lord Kitchener being shewn round H.M.S. "Iron Duke" by Capt. Dreyer, R.N.
Admiral Jellicoe in the background.

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VISIT OF LORD KITCHENER TO THE GRAND FLEET AT SCAPA FLOW.

THE photograph on the opposite page is one of a series of four which were taken on the occasion of the visit of Lord Kitchener to Admiral Jellicoe on board H.M.S. *Iron Duke*, the day on which he met his death by the sinking of H M.S. *Hampshire*, and which have been presented to the R.E. Museum by Sub-Lieut. G. Coffin, R.N., son of Major-General Clifford Coffin, V.C., D.S.O. The incident which is recorded in Admiral Lord Jellicoe's book, *The Grand Fleet*, 1914—16, is thus described by Lieut. Coffin :—

Lord Kitchener arrived at Thurso on 5th June, 1916, and was conveyed over to Scapa Flow in H.M.S. *Oak*, tender to the *Iron Duke*. He arrived aboard H.M.S. *Iron Duke* at about 11 a.m. and a tour of the ship was commenced. Lord Kitchener was shown round the ship by Capt. F. C. Dreyer, Flag Capt. to Admiral Jellicoe. He visited the conning tower, bridge, one of the turrets, and also the mess decks. After the tour the Field Marshal and his staff lunched with the Admiral, and at 2.30 Lord Kitchener left the *Iron Duke* in a drifter to embark aboard H.M.S. *Hampshire*. It was raining hard and a high sea was running.

This was the last seen of Lord Kitchener by the officers and men of the *Iron Duke*.

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THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914—1919.

(*Continued*).

BRIDGING. (PART III., SECTION 4).

CHAPTER I.

ORGANISATION AND SUPPLY OF MATERIAL.

Introduction.—First Orders for Steel Spans.—Heavy Pontoon Bridging Material.—Subsequent Orders for Steel Spans.—Characteristics and Developments of Types.—Bridging Depôts and Stores.—Special Bridging Staff Units.—Transport of Stock Spans.

1. *Introduction.*—At the beginning of the war the British Army not only was unprovided with special material for heavy bridging, but technical intelligence on which to base possible requirements was almost entirely lacking.

The need for heavy bridges was first experienced on the Aisne.

Some heavy timber girder and trestle bridges were built, but took too long to make and to erect, and the B.G., R.E. at General Headquarters promptly sent home a demand for steel spans.

At the end of November, 1914, Lieutenant Colonel W. A. Liddell (now Major-General Sir W. A. Liddell, K.C.M.G., C.B.) was appointed to the B.G., R.E.'s office for executive charge of roads and bridges in rear of Divisional R.E.

At that time there was only one army—later when a second was formed, the executive functions in respect of roads passed to Chief Engineers of Armies.

Compilation of Road and Bridge Maps.—The investigation of information regarding roads and bridges was at once commenced, and the work was done entirely in the B.G., R.E.'s office until the spring of 1916, when it was taken over by the Intelligence Section of the General Staff. The information was obtained with great difficulty, because most of the French departmental records of the area were left in Lille, and those of Belgium in Antwerp or Brussels—however, by the time the work was handed over to the Intelligence Section road and bridge maps as far south as the Somme, and as far east as the Escaut were practically completed.*

Details of the waterways in the area traversed by the Lys and its

*Further information on this subject will be found in a separate report on Engineer Intelligence.

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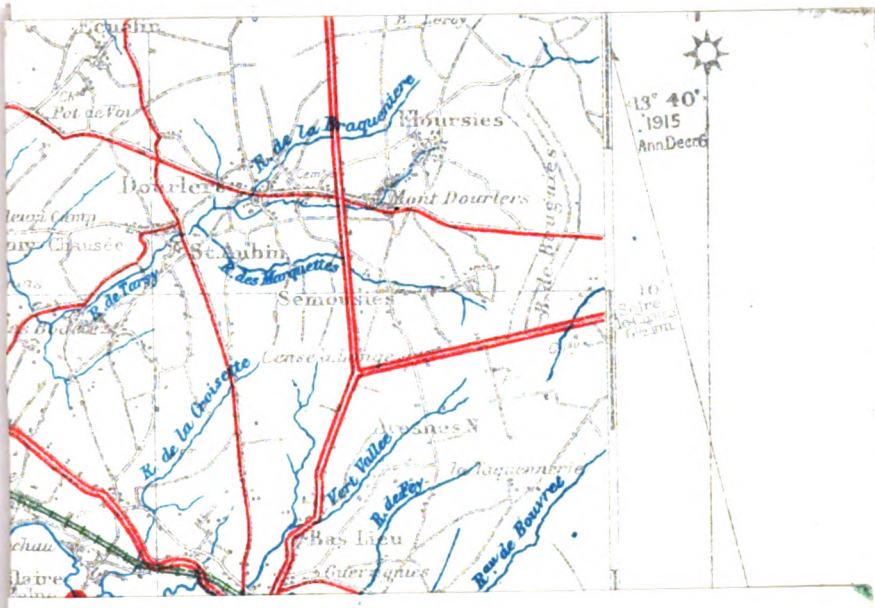

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PLATE I

CLASS OF BRIDGE

B

R. S. J. SPANS.

DECK.

SPANS

SPAN.

A

LIFTING BRIDGE. DAVIT PATTERN. 10'-0 ROADWAY.

R. S. J. SPAN THREE 18 x 7. 10'-0 ROADWAY

R.S.J. SPANS. TWO 18 x 7 5 TWO 6 x 6. 10'-0 ROADWAY.

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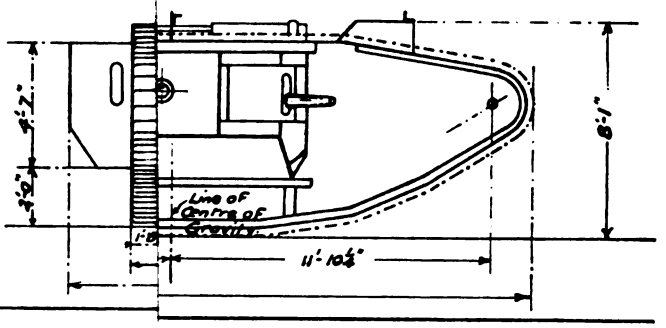
PLATE Ia.

— DIAGRAM OF TOTAL WEIGHT —
— SCALE ING ORDER = 30 TONS.



OX TOTAL WEIGHT —
IGHTING ORDER = 18 TONS. —

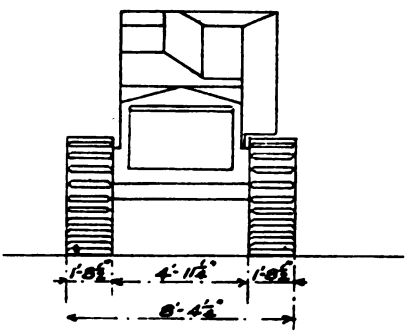


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PLATE II.

APPURTENANCES.

D/189.	30 ft. R. to 3.	Detail of Strengthening 85 ft. Span for Tanks.
D/246/1 to 4.	21 ft.	Pile Piers. Detail of junction of 19 ft. Span and Portal Span.
D/248/1 to 4.	16 ft. and 2.	Erection and Launching of 85 ft. Span.
D/270/1 to 10.	60 ft.	Detail of Splice for 12 in. × 12 in. Piles.
D/275/1 to 17.	21 ft. to 4.	30 ft. Reinforced Span as Lifting Portal.
DP/282/1 to 22.	Hop	Pier for junction of 85 ft. Class " A " and 30 ft. Reinforced.
DP/315/R.	Acc and 2.	Pile Pier of 85 ft. Class ' A " Spans.
DP/288/M.	Mod and 2.	Pile Pier for junction of 85 ft. and 30 ft. Spans, Class " A."
DP/364.	Ben	Girder for 30 ft. Reinforced Span in one Length.
DP/365.	to 12.	Hopkins Lorry Bridge.
DP/400.	Lau	Emergency Short Span Bridge for Tanks (for rapid Bridging).
DP/247/1 and 2.	Ste	This was a special case.
DP/413/1 to 16.	Hop	Diagram showing Distribution of a Heavy Bridging Company
DP/415/1.	We	for Simultaneous Work on an Army Front.
DP/416.	Fre..	Proposed Method of Transporting and Launching 21 ft. 6 in.
DP/420.	Pon	Span Bridge.
DP/446.	Pon..	Mobile Girder Bridge and Pontoon Bridge for 200 ft. River.
DP/447.	Dup and 2.	Standard Field Bridge, 20 ft. Span, for Tanks, now superseded
DP/448.	Pil	by DP/755.
DP/458/A.	Cen and 2	18 ft. Standard Field Bridge to carry Tanks. Superseded by
DP/503/A1 to A4.	Tar	DP/756.
DP/504.	Det to 3.	20 ft. Standard Field Bridge for 12T Axle Load. Superseded
DP/512/1 to 5.	30 ft	by DP/755/1 and 2
DP/514.	Dra to 3.	18 ft Standard Field Span for 12T Axle Load. Superseded by DP/756.
DP/515/1 to 5	19 ft	to 3. 20 ft. Standard Field Span for First Line Transport.
DP/515/8		to 3. 18 ft. " " " "
DP/519/1 to 3.	Em to 4.	Standard Field Davit Span for 12T Axle.
DP/530.	Pon to 3.	22 ft. R. S. J. Standard Field Bridge.
DP/541.	Lat to 3.	20 ft. " " "
DP/542	to 7.	American Steel Lattice Girder Bridge, 90 ft. Span.
DP/542/M.		Standard Trestle for use with R.S.J. Field Spans.
		Pile Piers for R.S.J. Standard Field Spans.
DP/542/MM.	and 2.	Launching Diagram for 180 ft. of Hopkins 120 ft. Type Span.
		Mark V. Male Tank—34 Tons.
DP/543/1 to 9R.	Por	Mark V. Male Tank—30 Tons.
DP/550/1 to 6.	Tin and 2.	Fittings for Hopkins 180 ft Span, 120 ft Type.
		Launching Roller for Item 152. H.B.23.A.
DP/551.	Fis to 3.	33 ft. Standard Field Span for Tanks and 12T Axle Load.
DP/552/1 and 2.	Tin	Special Spanners for Hopkins Bridge.
DP/557/1 to 15M.	Por M.	Motor Driver Friction Winch.
DP/556/1 to 5.	21	Cube Pier. Supersedes Plate 15, Revised.
DP/563/1 to 10.	Por .A.	Alteration to Pont Levis Bridge Mark II. for Lifting Arrange-
DP/566/1R and 2.	Alt	ment; Modification of A.13.
DP/573/1 and 2.	Pie	Wire Rope Slings and Forged Steel Shackles.
DP/575/1.	60	

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tributaries and the adjoining canals (Aire-La-Bassee, Ypres-Menin, etc.) were first obtained, and before the battle of Loos in September, 1916, maps and books for the immediate British front had been issued—a portion of one of the earlier sheets is reproduced (*Map* A.).

Diagrams of Loads, etc.—The next step was to work out technical details for the transport, assembling, and launching of the steel spans under order from England.

Great progress had already been made before the end of 1914, and many details were sent to England together with a diagram of loads, all of which were elaborated by the Inspector of Iron Structures, and incorporated in a book termed *Portable Road Bridges, and Diagrams of Roads and Bridges* issued from that office. A second volume was issued later to show the A.A. type bridges, and a complete new edition was in preparation at the time of the Armistice.

Plate I. is the original diagram of loads, and *Plate* IA. a diagram of tank loads.

Base Depôt, Havre.—Steel spans began to arrive early in 1915, and by the end of that year bridges of all types had been received, and were erected at the Base Park, Havre. Work of the very greatest value was done at this park, where not only were experiments of every kind carried out which led to many improvements in methods of erection, etc., but instruction was also given to a large number of R.E. officers and other ranks.

During practically the whole of 1915 and 1916 classes were continually held under the supervision of the O.C. Base Park in addition to his normal duties. The work ultimately became far too heavy, and the formation of a proper bridging school was finally approved. This is fully described in the Appendix.

Memo. on Road Bridges.—During the summer of 1915 the first edition of *Memo. on Construction and Repair of Road Bridges* was issued from the Engineer-in-Chief's office. This was mainly compiled from the results of experience obtained by the O.C. Base Park, to whose foresight, zeal, and unremitting work much of the later success of the organisation for heavy bridging operations is due.

At the end of 1917, a pamphlet on *The Organisation of Bridging Work* was issued based on the practical experience gained in the crossing of the Somme at the beginning of that year.

During the summer of 1918 a completely new edition of *The Memo. on Road Bridges* was brought out in which the contents of all the previous publications were embodied and brought up to date.

A regular series of drawings and publications dealing with stock spans and bridging appurtenances was issued from time to time during the war from the Engineer-in-Chief's office.

A complete list of these is given on *Plate* II.

Development of Organisation.—It will be easily understood that an enormous amount of work was involved in developing the details

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of what was comparatively a new subject in field military engineering; of course there had been a great deal of rapid railway bridge work in the South African War, but the conditions in France were different, and it was seen that the rate of advance of an army fed and supplied mainly by motor transport, and with a very large proportion of heavy artillery, would depend in a measure on the rapidity with which heavy bridges could be constructed.

The width of the front demanded a large number of bridges to be constructed simultaneously, with labour which could only be partly skilled, consequently the organisation of supply of materials, namely—storage, sorting, loading and despatch, reception near site, and transport, had to be perfected, and full instructions for erection had to be formulated, based on local conditions. Types of bridges had to be standardised after experiment, and also methods of erection to compensate for the lack of fully skilled labour and superintendence.

Field Engineers.—The appointment of field engineers (civil engineers of good technical experience) made early in 1915 was partly designed with a view to the superintendence of heavy bridging work. At the time the amount of bridging work in progress did not require specially appointed officers, but as demands for bridges increased, the field engineers gradually were taken on to the staff of C.E.'s of corps and armies as bridging officers; similarly in the E. in C.'s office a succession of temporary field engineers and the staff of the bridging school all contributed to the gradual development of the organisation.

Engineering Stores Directorate.—On the formation of the Directorate of Engineering Stores in the summer of 1918, the whole supply of heavy bridging materials and stores was taken over by the new director, who was also responsible after the Armistice for the disposal of all surplus material and stores, as well as for the sale of bridges *in situ* to the French and Belgians. The compilation of exact records of all the bridges erected was a long and difficult job. This was done in the office of the Engineer-in-Chief, as well as the valuation of all bridges, the statistics being finally handed over to the D.E.S. for completion of the business part of the sales.

Steel bridges were valued solely on the weight of metal at an agreed price per ton, all timber and fittings being thrown in gratis.

French, Belgian and American Organisation.—The French had six heavy bridging specialist companies in 1915—16, but their bridge spans were largely improvised from ships' plate, and the companies were manned by dockyard *personnel.*

The types of bridges were not satisfactory; they would not carry our heaviest ordnance nor their own, and the roadway and clearances were also insufficient; these were revised later on.

The Belgians depended mainly on wooden girder bridges on wooden piles, but their material and stock were very scanty.

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The French bridging on the Yser Canal during the Passchendaele attack in 1917 was done almost entirely with material supplied to them by the British Army.

The Americans fully recognised the necessity for large supplies of steel bridges, and decided to adopt the British types generally. After careful investigation they decided to produce a modified pattern of the 60-ft. span, in which the cross girders and flooring were raised so as to allow the sponsons of tanks to ride over the girders.

An agreement was made under which a number of these new spans were to be supplied to us by the American Army in return for an equivalent weight of Hopkins' 30-ft. and 21-ft. 6-in. bridges—none of the new type had been actually delivered before hostilities ceased.

2. *First Orders for Steel Spans.*—At the beginning of October, 1914, a letter was drafted by the Brigadier-General, R.E., at G.H.Q., and sent to the War Office under the signature of the Commander-in-Chief, asking for the provision of material for 16 steel girder bridges, together with an adequate supply of pile drivers and monkeys. These bridges were to be capable of carrying the heaviest loads then in the country (8-in. howitzer—13 tons on one axle).

The actual designs were made at the office of the Inspector of Iron Structures, with the following limitations laid down by the B.G., R.E., France :—

(*a*) Maximum length of one piece not to exceed 25 ft.
(*b*) Width of one piece not to exceed 7 ft. 6 in.
(*c*) Weight of one piece not to exceed 3½ tons.

The first order was actually placed at the beginning of December for 4,140 ft. run in 13-ft., 30-ft. and 60-ft. lengths, and deliveries were promised to begin by the end of December. Before many of these were received, the introduction of the 6-in. Mark VII gun on Naval Carriage had increased the maximum axle load to 17 tons, and in March, 1915, another order was given for bridges to carry this load in lengths of 16 ft., 21 ft. 6 in., 30 ft., 60 ft. and 85 ft. ; also in January, 1915, the first order was given for Lifting Bridges for use on navigable canals. The design for these was got out in the office of the B.G., R.E., France.

The bridges to carry 13 tons axle load were termed B type bridges. Those to carry 17 tons axle load A type bridges.

Manufacture of these first two orders was pressed on with the greatest possible speed.

At the beginning of 1915 the military situation made it clear that there would be no immediate use for these bridges, and considerable difficulty was found in providing storage space for them at the base as they arrived.

The War Office pointed out that extraordinary exertions had been

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made by all concerned in the bridge production, and that it was very desirable that there should be no delay in accepting delivery.

With some difficulty yard room was arranged at Havre, and this developed into the permanent heavy bridging depôt, and remained as such throughout the whole of the war.

3. *Heavy Pontoon Bridging Material.*—In the early days of the war the War Office took up the question of heavy floating bridges that might be required for the passage of the Rhine in the event of operations being carried into the enemy's country.

The design was got out for a heavy pontoon to carry the maximum load of a 14 tons traction engine across a river 500 yards broad, with a minimum current of five miles an hour. A special steel pontoon was designed 45 ft. long, 4 ft. deep, and 8 ft. beam, weight of each pontoon approximately 5 tons, weight of super-structure of each pontoon 3½ tons, clear waterway 12 ft. The earliest date of delivery quoted was the end of July, 1915.

At the beginning of March, 1915, the War Office wrote to the C.-in-C., B.E.F., France, asking :—

(i) Whether it was desirable to arrange for supply of this material.
(ii) Whether the design was considered suitable.
(iii) Whether two bridges, each of 500 yards length, should be provided for, or one only.
(iv) Whether the date of earliest delivery was considered suitable.

The higher authorities in France were unanimous in expressing the opinion that the British Army was unlikely to be called on to bridge the river Rhine in the course of active operations.

The Chief of the General Staff considered that material should be provided for not less than 20 bridges, capable of carrying the heaviest loads over the Upper Scheldt, the Dendre, and the Meuse, and 10 over the river Lys.

The B.G., R.E., insisted on the advantages of steel girders resting on fixed foundations over any form of floating bridge, and a reply was accordingly sent to the War Office deprecating the expenditure of valuable time and material on floating bridge equipment.

Owing to the enormous pressure of other work at home, the additional steel bridges required by the C.G.S. were not ordered for the moment.

Meanwhile experiments were continued by the Deputy Director of Works attached to the office of the B.G., R.E., in the fitting out of standard French 280 tons barges so as to form road bridges with cuts for canal traffic.

4. *Subsequent Orders for Steel Spans.*—At the beginning of October, 1915, the Engineer-in-Chief obtained authority to order approximately

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10,000 ft. run additional steel bridging in spans varying from 16 ft. to 85 ft. The reasons given for the necessity of this order were, first, that the size of the British Army had been more than doubled, secondly, that we had a liability to provide the French Army with material for 12 heavy bridges in case of an advance as far as Valenciennes, and that we should probably also have to supply the Belgian Army. The total amount now on order was calculated to allow about 10 bridges per Army Corps, which was thought to be the minimum that was likely to be wanted, allowing for 20 Corps British and French in line.

The situation was next reviewed by the Engineer-in-Chief in January, 1916, in a letter to the Quartermaster-General, giving details of material received up to date. He also reported that three fleets of equipment barges were completed, and a fouth nearly ready. A certain number of Inglis type bridges had also been ordered.

The E. in C. pointed out that there was no alteration in the military situation, and recommended that no further orders for bridging material should be given at present.

In April, 1917, the Engineer-in-Chief wrote to the C.G.S., and to Q.M.G., again reviewing the situation in the light of the experience gained by the Fourth Army in crossing the Somme, and also of the much fuller information that had become available as to bridges in the country in front of us.

He also pointed out that neither the French nor Belgians appeared to have made any serious provision for heavy bridging, and also drew attention to the extra requirements of light railways. A table was drawn up showing the number of bridges that might be required for an advance of 50 miles beyond the present line, and numbers of spans actually available.

Authority was asked to order 50 each of the following Class A spans—85-ft., 60-ft., 21-ft. 6-in., and 16-ft.

Changes due to Introduction of Tanks.—During 1917 considerable modifications had to be made to practically all the type spans owing to the introduction of tanks, which increased the maximum load to be carried from 17 tons to 30 tons. Certain of the stock spans could not be converted to carry this increased load, and consequently fell into disuse later on. The question of roadway clearance and head room was carefully investigated, and the G.O.C. Tank Corps decided that no alteration of design was required in these respects.

The stock spans generally gave a clear roadway of 10 ft., which, although insufficient for tanks with sponsons out, was ample when sponsons were turned in, and no difficulty was anticipated in doing this when necessary. In actual experience this view was not confirmed, and during the first half of 1918 a certain number of tanks were probably lost owing to the impossibility of turning in sponsons in emergency.

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The new and converted bridges were termed A.A. type.

The retreat in March and April, 1918, also cost the loss or destruction of a quantity of heavy bridging material, estimated to amount to about 17,000 ft. run.

These points were brought forward in a letter from the E. in C., to the C.G.S. in May, 1918. For these and other reasons it was considered that the material still in hand or under order would only provide for a 30-mile advance, instead of 50 miles, and a further large order was recommended calculated on an additional 50-mile advance.

It was also recommended that 25 per cent. of the new bridges should be of an increased width to allow of the passage of tanks with sponsons out.

During the year 1918 the situation was constantly reviewed, and every effort made to hasten deliveries, though this was found to be almost impossible owing to the very full programme of work at home, and difficulties in the supply of raw material.

Only a portion of the spans ordered were received before the Armistice, when outstanding orders were at once cancelled.

In October, 1918, a further extensive order was made out to be spread over most of the following year, but this was cancelled after the Armistice.

The following is a summary of the quantities of heavy bridging material ordered during the war :—

October, 1914.—4,140 ft. run (B type span). Length of spans—13 ft., 30 ft., 60 ft.

March, 1915.—7,473 ft. run (A type span). Length of spans—16 ft., 21 ft. 6 in., 30 ft., 60 ft., 85 ft.

October, 1915.—10,425 ft. run (A type span). Length of spans—16 ft., 21 ft. 6 in., 30 ft., 60 ft., 85 ft.

April, 1917.—9,130 ft. run (A type span). 16 ft., 21 ft. 6 in., 60 ft., 85 ft.

May, 1918.—21,250 ft. run (A and A.A. type spans). 21 ft. 6 in., 30 ft., 75 ft., 120 ft.

Supplies of heavy baulk and other timber for piles, seatings, roadway, etc., in proportion in each case.

5. *Characteristics and Development of Types.—B Type Bridges.*—The 13-ft. bridge consisted of four 12 in. × 6 in. rolled steel joists.

The 30-ft. and 60-ft. types each consisted of two light Warren girders.

The earliest of these sent to France were all deck spans, but modifications were introduced to make them capable of being used as either deck or through spans, as it was found that in many cases the deck span did not allow sufficient head room on navigable canals.

A Type Bridges.—The 16-ft., 21-ft. 6-in. and 30-ft. were all manufactured rolled steel joist spans.

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The 60-ft. and 85-ft. consisted of heavy Warren girders. The 21-ft. 6-in., 30-ft. and 60-ft. types are illustrated in *Plates* III. to IX.

A.A. Type Bridges.—Modifications were made in the 16-ft., 21-ft. 6-in., 30-ft. and 60-ft. bridges, to carry the extra load. In the case of the 60-ft. all that was found necessary was an increase in the size of the bolts.

The 30-ft. A span was weak, and to use up the existing spans, the 30-ft. reinforced bridge was designed, in which four existing girders were used instead of three as in the A span. In the A span the rolled steel joist girders are jointed, but when new spans were ordered the girders were made in a single piece 33 ft. long. This extra length had been made feasible by the introduction of Berna lorries, fitted with a special arrangement of rollers for carrying long timbers or girders.

The 85-ft. type had never been popular owing to the great weight (66 cwt.) of a single section, so the opportunity was taken to design a new bridge. *Photograph* I. shows an 85-ft. span.

Hopkins' 120-ft. Type Span.—The following specification was laid down :—

(*a*) The bridge should carry tanks.
(*b*) The total weight of the bridge should not be more than the weight of the old 85-ft. span.
(*c*) The heaviest single piece should not weigh more than 30 cwt.
(*d*) The number of bolts should not be unduly increased.

These conditions were completely satisfied by the Hopkins' bridge. The bridge can be made up in any multiples of 15-ft. spans, and carries tanks over a 150-ft. span, and a 17-ton axle load up to 195-ft. span. The total weight of the steel work is 43 tons for a 90-ft. length, as compared to 53 tons for the original 85-ft. span. The heaviest section only weighs 10½ cwt., and the number of bolts for a 90-ft. length is the same as that in the 85-ft. class A span.

The main feature of this bridge is the depth of the lattice girders, which are 16 ft. 3 in. over all, with overhead bracing.

The general arrangement of this bridge is shown on *Plate* X. *Photographs* II. to IV. illustrate erecting and launching at the bridging school.

Hopkins 75-ft. Type.—The Hopkins' 120-ft. type was found so satisfactory, that at the beginning of 1918 a similar bridge of slightly lighter design was ordered in 75-ft. span, and would have ultimately replaced the 60-ft. type bridge.

This 75-ft. Hopkins carries tanks up to 90-ft. span, and 17-ton axle load up to 105-ft. span. It weighs a few tons less for a 60-ft. length than the 60-ft. class A bridge. See *Photographs* V. and VI.

Hopkins Lorry Bridge.—In the autumn of 1918 a very light lattice

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girder bridge was designed to carry loads up to 5-ton lorries over a 75-ft. span. This bridge was still in the experimental stage at the time of the Armistice. The only one that was actually received in France was erected at the bridging school during the last class held there. Both instructors and students were unacquainted with the bridge, but a 60-ft. length was built, launched, decked, and approach ramps fitted ready for traffic in five hours. This is illustrated in *Photographs* VII. and VIII.

Lifting Bridges.—Belgium and Northern France are cut up by a network of canals, along which a great quantity of war material was conveyed, and which it was consequently necessary to keep open for traffic. These canals could often be bridged by erecting high level bridges, but in very many cases the same result was more easily attained by using lifting bridges.

The maximum width of locks is 6·50 metres (21 ft. 4 in.), so 21 ft. 6 in. was made the standard span for British lifting bridges.

The first types supplied were 21-ft. 6-in. class A spans, with the addition of lifting gear. These were made in three patterns, the Davit Bridge, the Portal Bridge, and the *Pont Levis*. Of these the first two were supplied by the War Office, and the third was manufactured in France, from designs got at the Base Park, Havre, and modelled on the local French 16-ft. span *pont levis*.

The Davit Bridge consisted of four lattice davits, with a lifting gear of differential blocks, by means of which the four corners of the bridge could be raised.

There was no counter-weight of any kind, and if the four corners were not lifted evenly the bridge was apt to jamb.

It was difficult to erect accurately, and required four men to raise or lower it, and not being found satisfactory, was soon given up for field use.

This type was originally intended for improvised low level bridges on canals where the footings of formerly existing bridges had been damaged by explosion.

The Portal Bridge consisted of four columns braced together with shallow lattice bracing girders at the top, both across the roadway and across the canal, and the lifting gear consisted of a worm gear arrangement with a hand chain for working it, and there was also a counter-weight equal to the weight of the bridge. The lifting arrangement was weak, and trouble was also caused by the fact that bridges were supplied by four different makers, each to their own detailed drawings, so that spares were not interchangeable. It was an easy bridge to erect, and failing a better pattern a good many were used.

The Pont Levis consists of two independent towers with overhead arms carrying a counter-weight between them at one end, the bridge being suspended by wire ropes at the other end. The lifting apparatus

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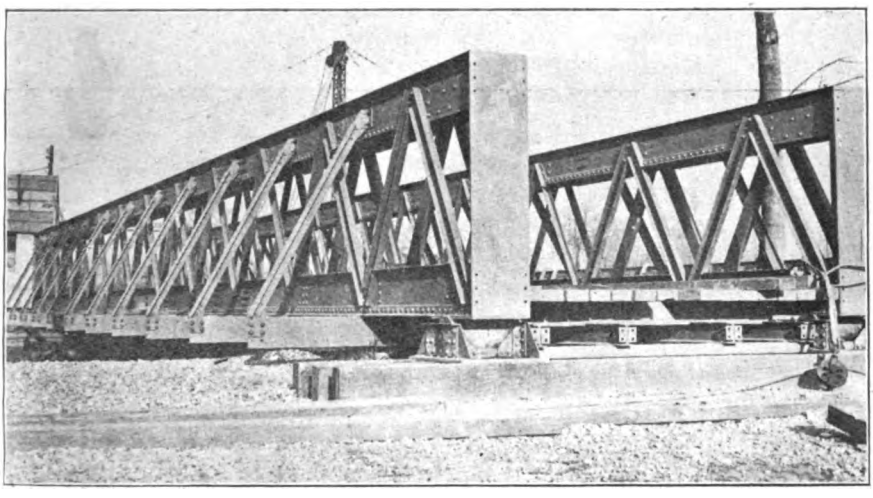
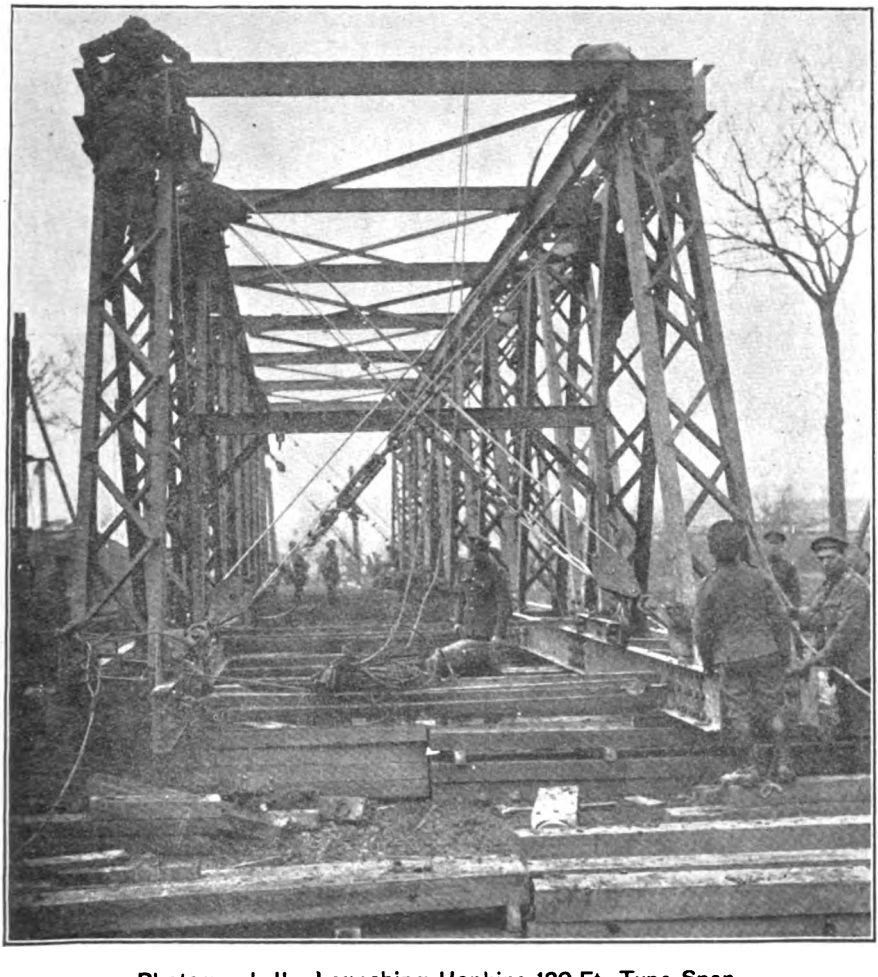


Photograph I.—85-Ft. Class "A" Span.



Photograph II.—Launching Hopkins 120-Ft. Type Span.
View from near bank, showing temporary wire rope cross bracing.

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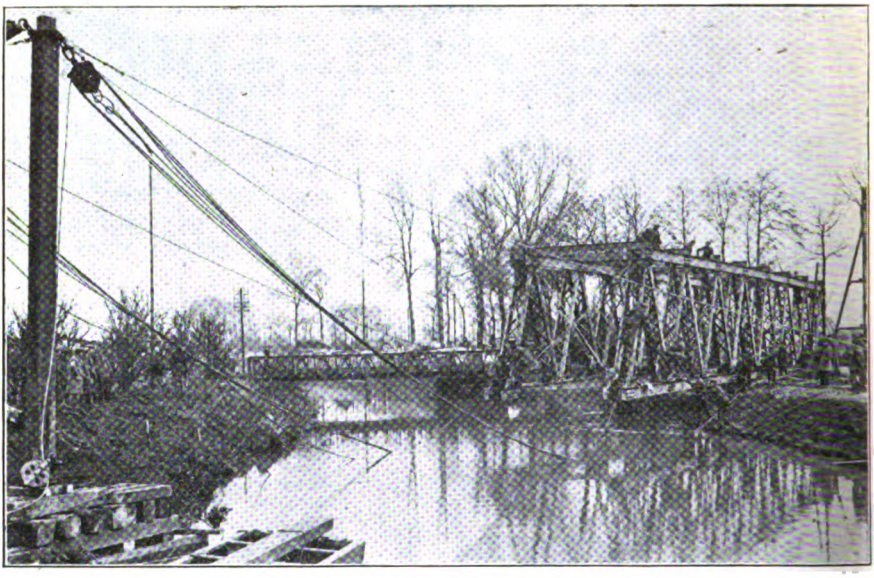

Photograph III.—Launching Hopkins 120-Ft. Type Span.
Span launched 45 ft. Fixing slings for main launching tackle.

Photograph IV.—Launching Hopkins 120-Ft. Type Span.
Span launched 100 ft.

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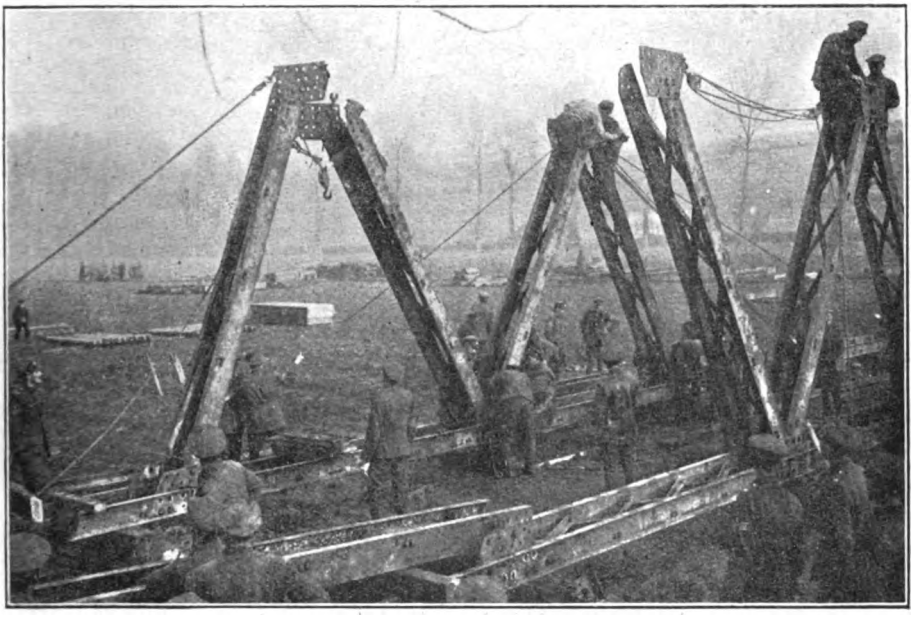
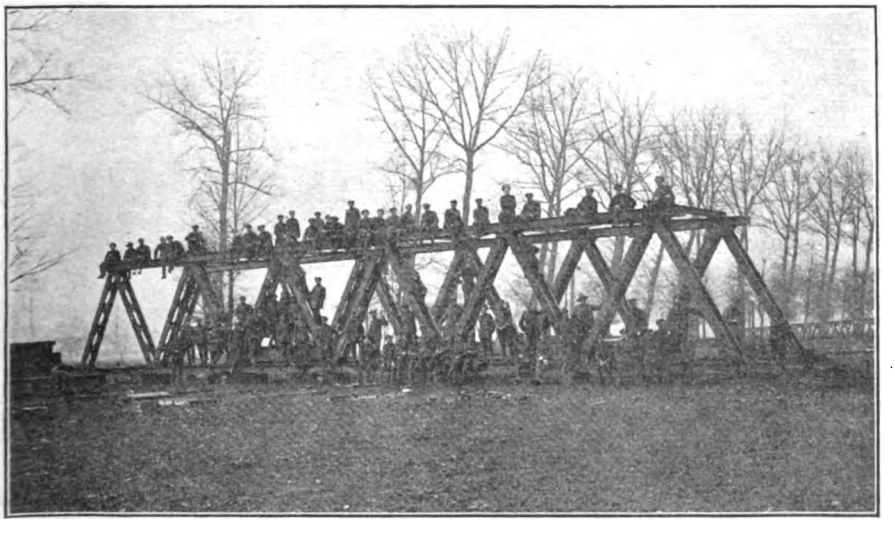


Photograph V.—Hopkins 75-Ft. Type.



Photograph VI.—Hopkins 75-Ft. Type.

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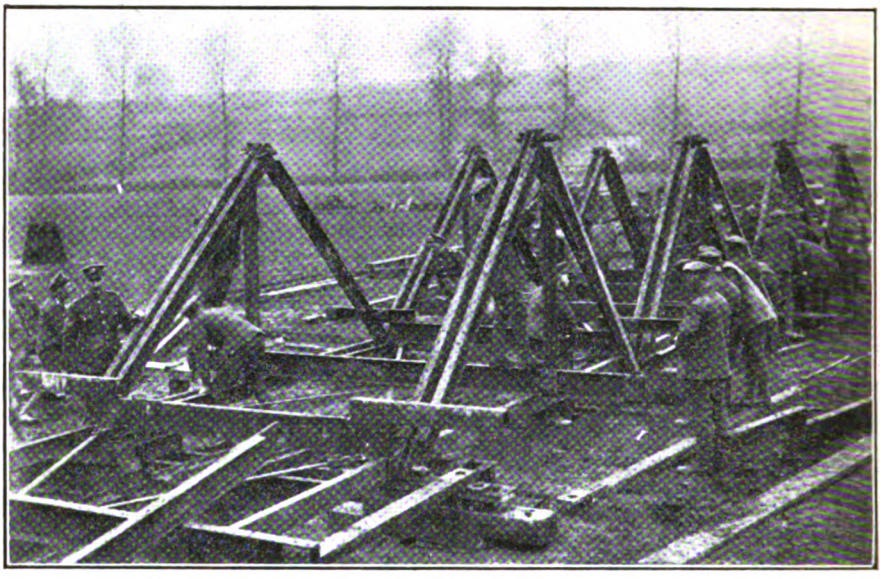
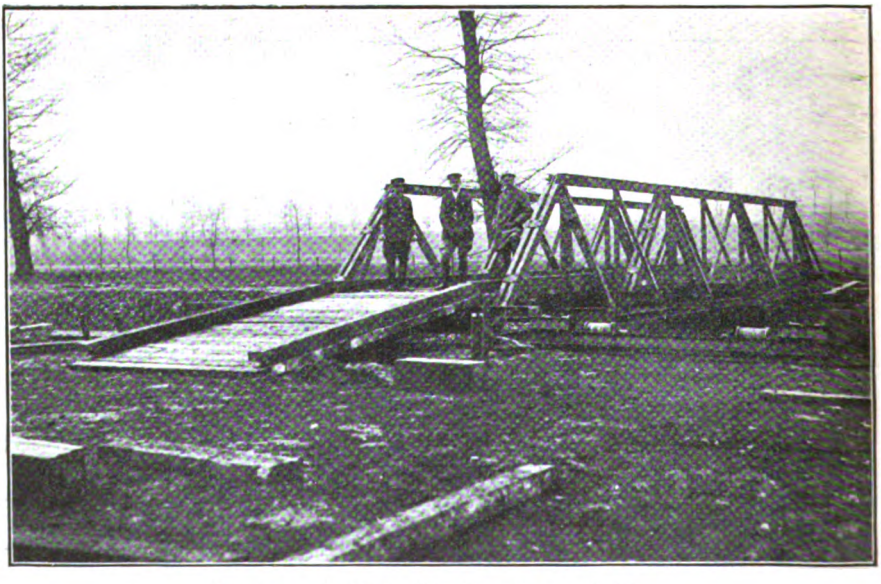


Photograph VII.—Hopkins Lorry Bridge.



Photograph VIII.—Hopkins Lorry Bridge.

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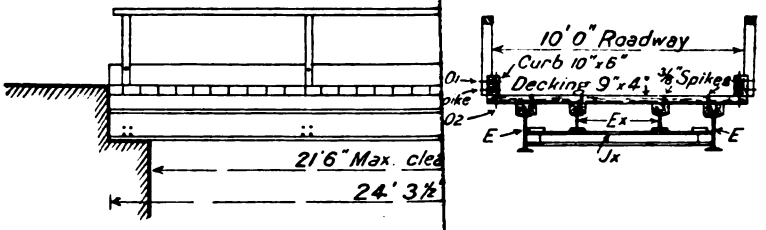
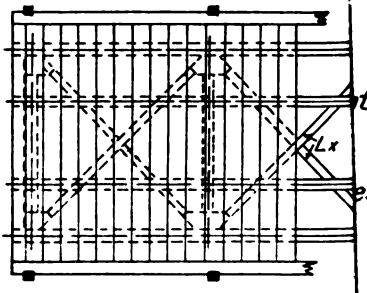
PLATE III.

R.S.J. SPAN. CLASS "A."

The 16'





	T.	C.	Q.	L.
t of Bridge.....	6	3	3	6
" I Girder.....	1	0	0	20
est Member.....	1	0	0	20

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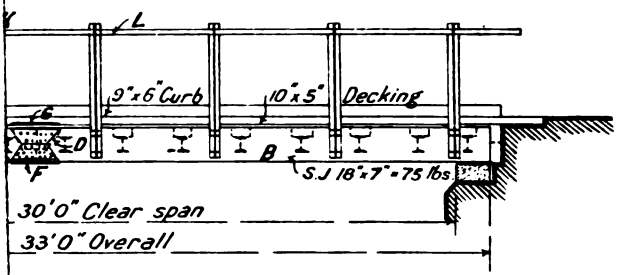
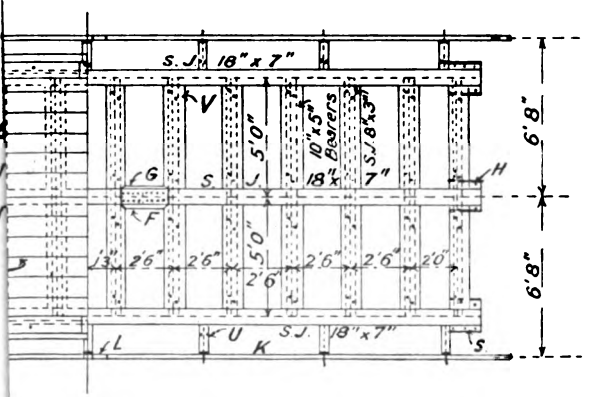
PLATE IV.

SPAN—CLASS "A."





Weight of Bridge

" " I Girder

Heaviest Member

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PLATE V.

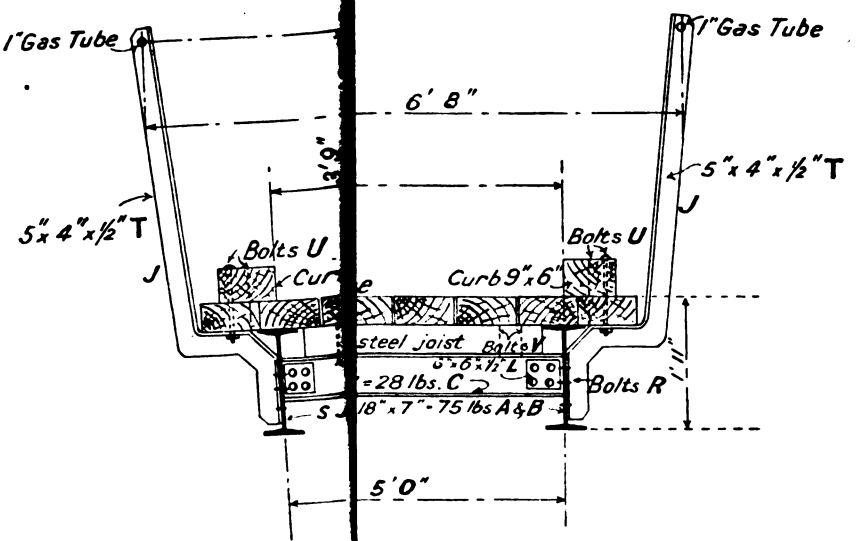

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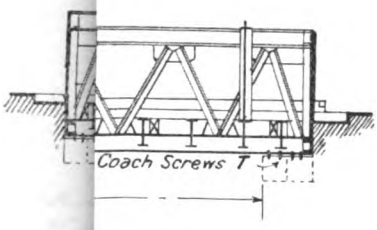
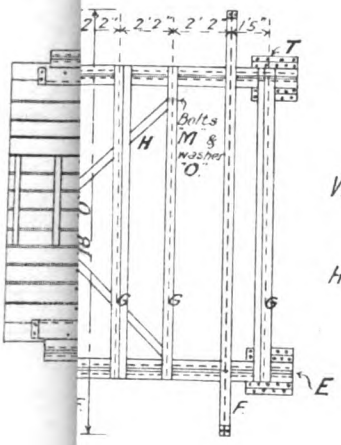
PLATE VI.

PC FT. ROADWAY.





	T.	C.	Q.	L.
Weight of Bridge	32	12	2	3
" " 1 Girder	6	3	3	21
Heaviest Member	1	8	1	17

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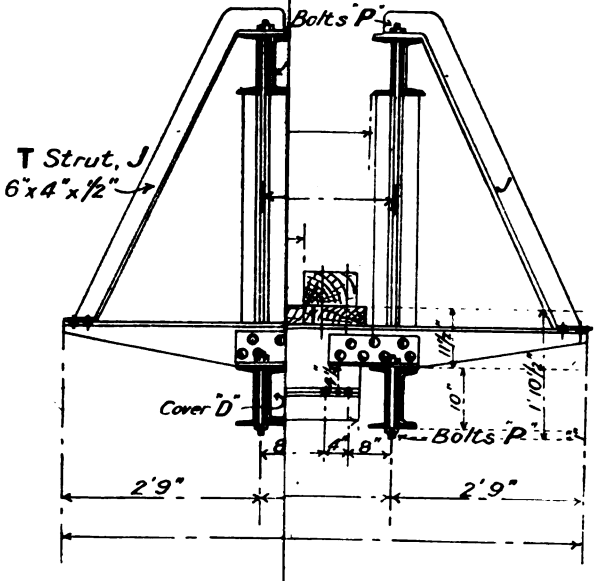
PLATE VII.



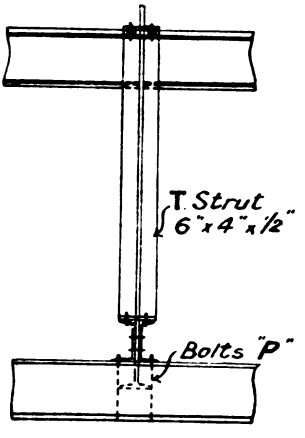


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PLATE VIII.

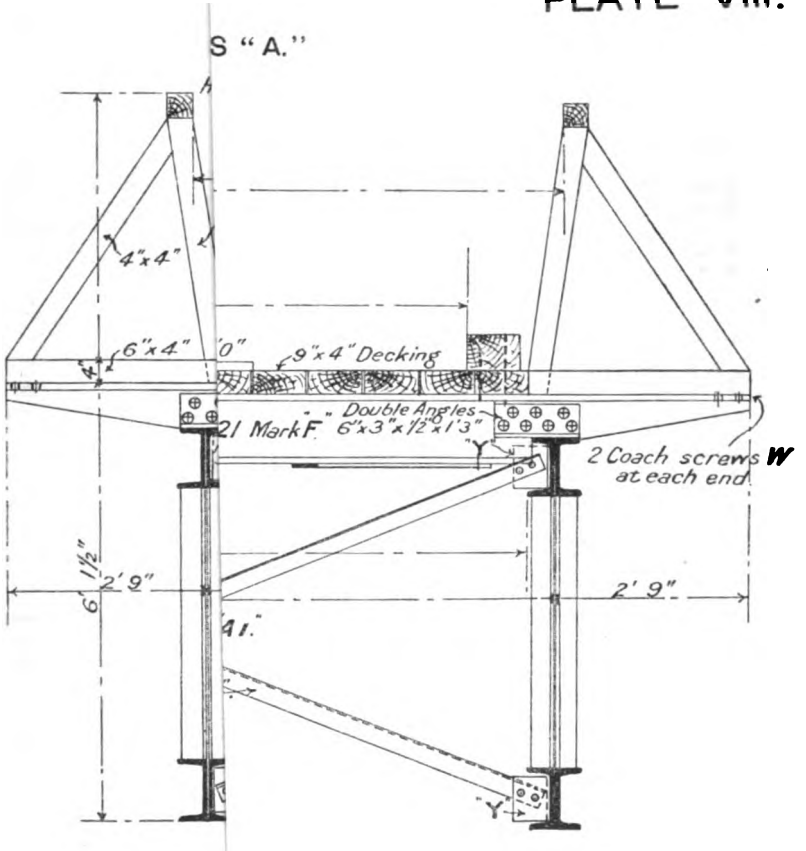

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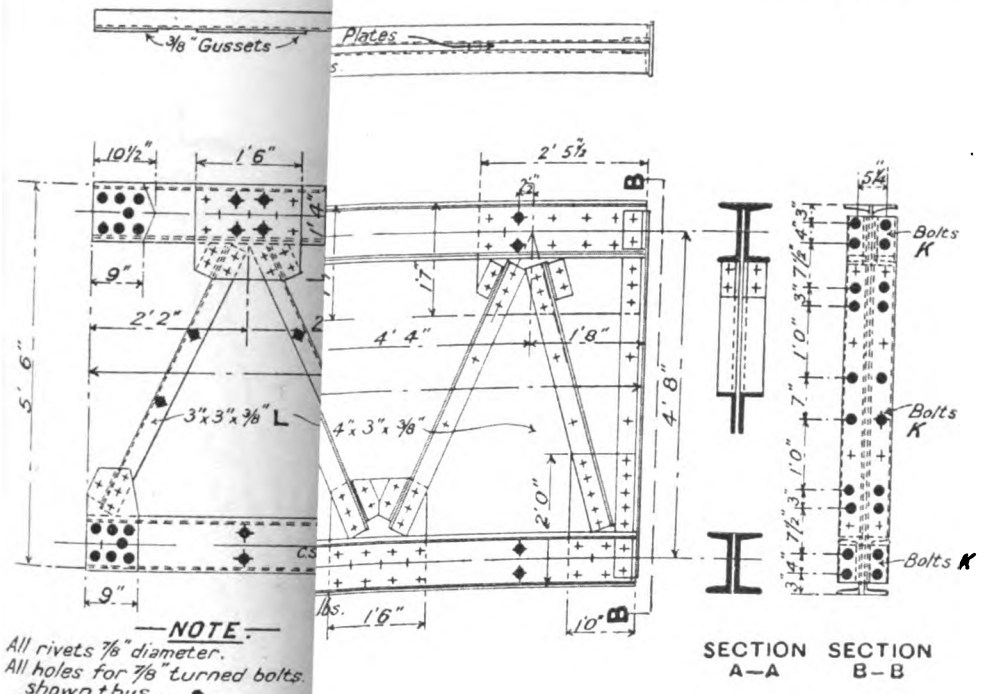
PLATE IX.



NOTE.

All rivets ⅞" diameter.
All holes for ⅞" turned bolts shown thus .... ●
⅞" Diameter holes for ¾" bla
All holes carefully drilled
that each section of girde
and may be fixed in any

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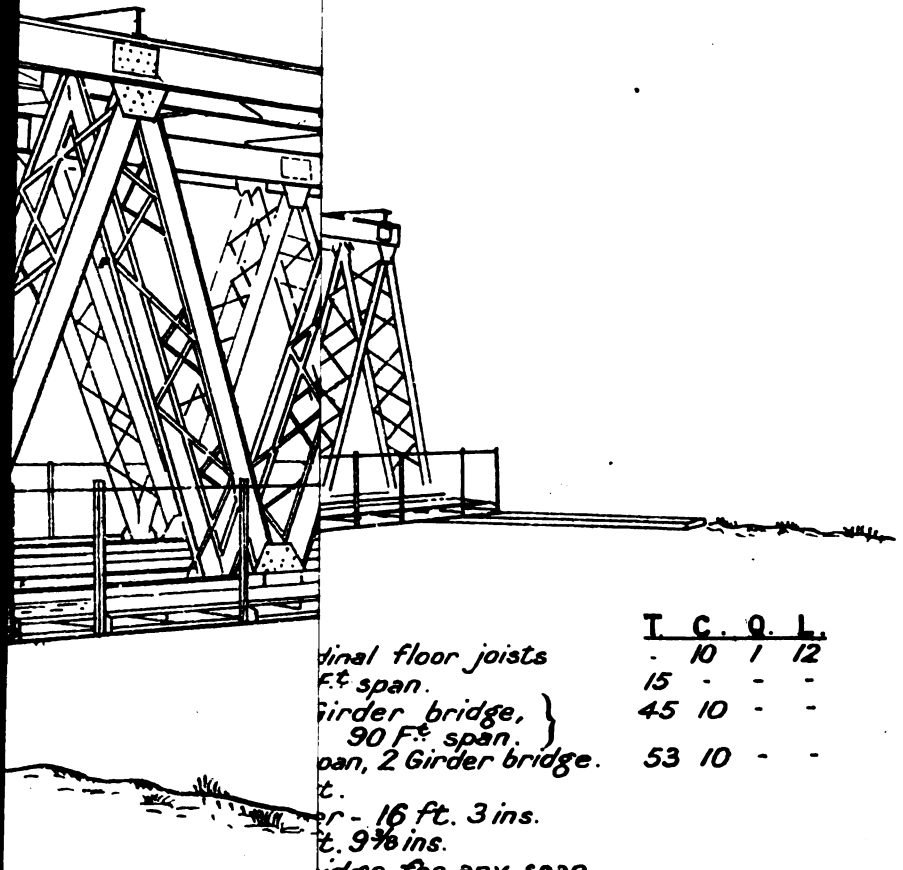
DGE — H

PLATE X.



	T.	C.	Q.	L.
dinal floor joists	-	10	1	12
Ft. span.	15	-	-	-
Girder bridge, 90 Ft. span.	45	10	-	-
pan, 2 Girder bridge.	53	10	-	-

t.
er - 16 ft. 3 ins.
t. 9⅛ ins.
idge for any span
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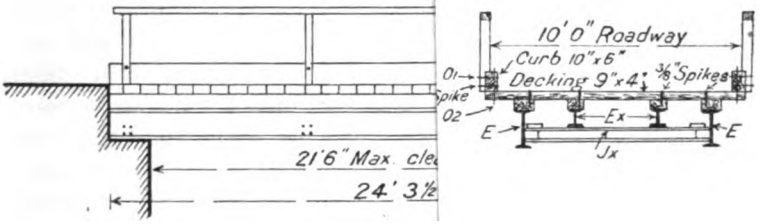
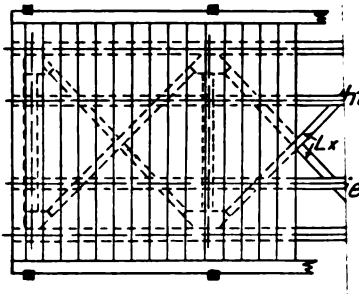
PLATE III.

R.S.J. SPAN. [illegible]SS "A."

The 16





	T.	C.	Q.	L.
[illegible]ht of Bridge.....	6	3	3	6
" I Girder.....	1	0	0	20
[illegible]est Member.....	1	0	0	20

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consisted of a wire rope attached to the bridge, and led through a pulley at the top of the tower, thence being taken on to a 1-ton winch by means of which the bridge was lifted. This bridge was rather difficult to erect because it required very accurate setting out. *Photograph* IX. shows a bridge that had just been erected at the school. The derrick on the left was used for erection purposes only.

Pont Levis Mark II.—Later a new design was got out, in which the bridge proper consisted of two special plate girders with cross girders and longitudinals in place of the standard 21-ft. 6-in. class A span. The two columns were erected on a pier of rolled steel joists, which tied them together; the hinges of the bridges were carried on the column bases, so that no setting out was required once the base joists were laid. This bridge was heavier than the others, but was the most satisfactory type produced, and the weight of each individual piece was actually less than in the Pont Levis Mark I. The general arrangement of this bridge is shown on *Plate* XI.

The Emergency Portal.—This was an emergency design to carry 12-ton axle loads. It was only erected in places where it could normally remain either up or down, and would only be moved in cases of emergency.

The bridge consisted of four uprights braced together at the top as in the ordinary Portal, but with standard rolled steel joists instead of lattice bracing. For lifting apparatus the differential tackles from the discarded Davit Bridges were used.

Rolled Steel Joist Spans.—A type of bridge that was extensively used during the last months of the war was built up of stock rolled steel joists from the base. A large number of 12 in. × 5 in. × 22 ft., and 10 in. × 5 in. × 20 ft. joists were ordered specially for bridge work, and in addition use was freely made of supplies imported for gun emplacements and other defensive work.

Designs were prepared in the Engineer-in-Chief's office for standard field spans to carry various loads. They consisted of rolled steel joists laid side by side in the number necessary for the traffic that the bridge was to carry, *e.g.*, 6 joists for a 12-ton axle load, 8 for a 16-ton axle load, and 12 for a 30-ton tank. The decking of these bridges consisted of local timber, generally 2 to 3 in. layers, which was normally supplied ready cut from the base. These bridges were very easily and quickly erected. They were economical for light loads, but rather extravagant for heavy loads. The 22-ft. patterns for tanks and 12-ton axle load are shown on *Plates* XII. and XIII.

Inglis Bridges.—The Inglis pattern portable bridge consists of a series of identical bays formed of weldless steel tubes. In the original or light type, the bays were pyramidical, each 8 ft. long, 8 ft. wide, and 8 ft. high, and the bridge was designed to carry infantry in single file over a span of 120 ft.

At the first demonstration with this bridge in France, a 108-ft

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span was thrown across a canal in 13 minutes by an untrained party of Army Service Corps.

The second pattern was similar to the first, but the bays were 12 ft. long, 12 ft. wide, and 12 ft. high. This was designed to carry all arms, with their first line transport, up to not exceeding 7 tons in weight, over a span of 96 ft. The triangular section of this bridge made it unsuitable for the passage of mechanical transport, and in practice it was never used. (See *Photograph* X.)

Both types were also designed to be used in pairs with a central suspended decking. (See *Photograph* XI.)

Early in 1917 a rectangular pattern Inglis bridge began to arrive in France capable of carrying A loads over a span of 96 ft. or B loads over 108 ft. This bridge was easily erected or dismantled, and was in great request during the final advance. It was not strong enough to carry tanks over any span, and also had the disadvantage of being just too low for the passage of motor buses. *Photograph* XII. shows one bay under test, and *Photograph* XIII. a completed bridge.

A drawback to all bridges of this type is the expense and also slowness of manufacture.

At the end of the war a strengthened type was under experiment to carry tanks—this is shown in *Photographs* XIV. and XV.

Barge Bridges.—For each of the Army Barge Bridge Depôts two specially fitted up turn-table barges were provided, each equipped with double roadway and cut span for floating bridges, one 60-ft. class B through span erected on turn-table, one set of shore trestles complete with roadway and cut.

When it was required to bridge a gap, the 60-ft. span could be swivelled round, and water pumped into the barge to lower it until the bridge came to bear on the abutments. In addition, each of the six store barges in each Army Depôt was fitted with trestles and superstructure calculated to carry an axle load of 16 tons, and could be used as a pier for a floating bridge, with double roadway. It was calculated that with three such barges and shore trestles, a bridge could be made across most of the French or Belgian canals. In actual practice these bridges were never utilised owing to the destruction of canals and great difficulty and length of time experienced in re-opening them for traffic.

Special Barge Bridge.—In July, 1917, a special floating bridge was designed for the passage of the Yser River, to be used in connection with a proposed landing from the sea. This bridge was to consist of four 60-ft. A spans, carried each on two sea-going Thames lighters (60—70 tons). The barges were to be lashed together for conveyance of the bridges to the site, and there spread apart so as to be one under each end of the span. In this case the spans were fixed at right-angles to the barges, and not along them as in the case of the turn-table bridges. Owing to the cancellation of the military

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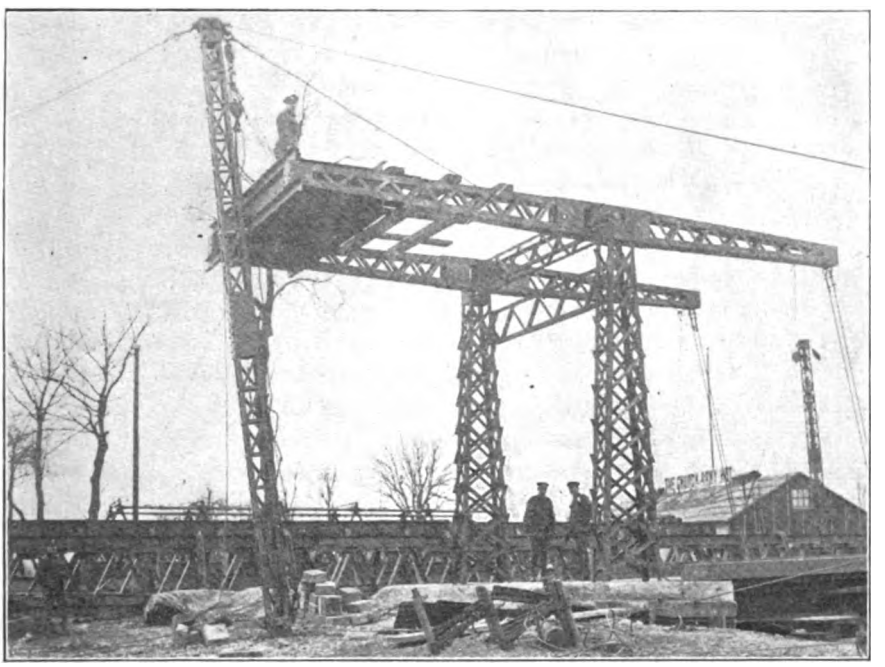

Photograph IX.—Pont Levis.
Showing derrick used in erection.

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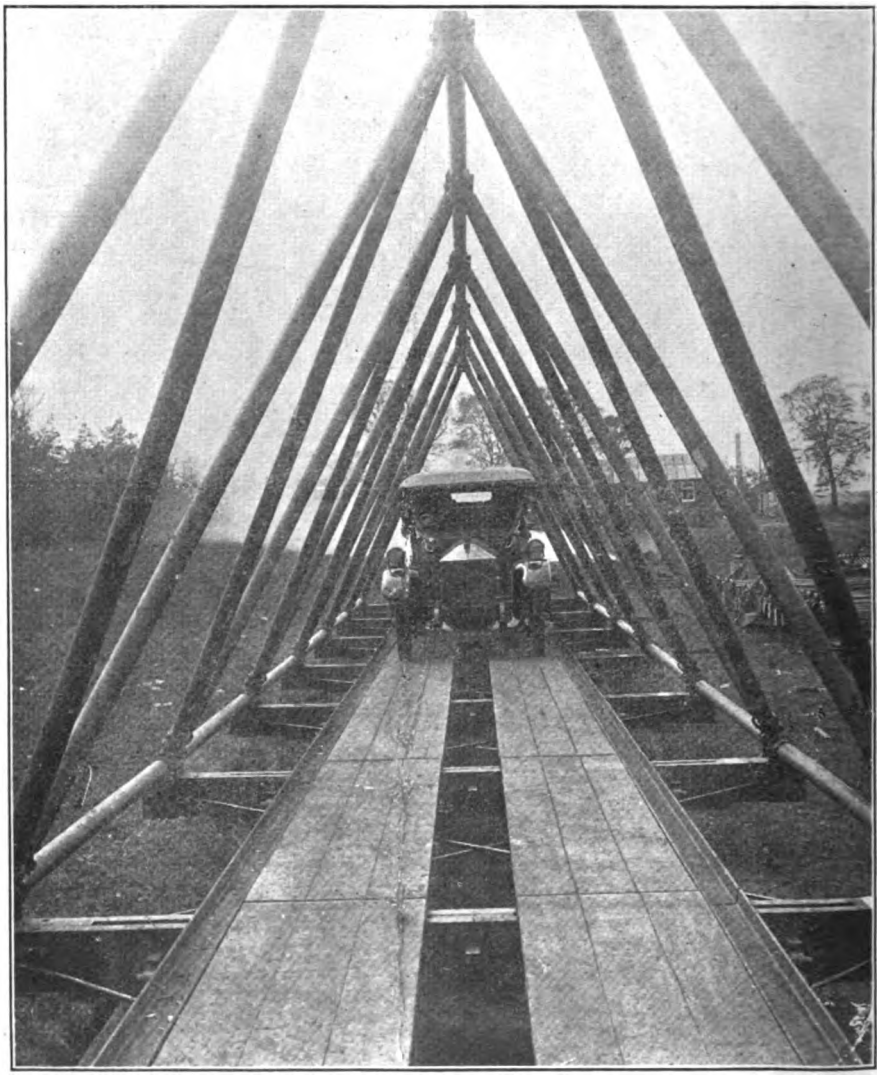

Photograph X.—Inglis Bridge: Second Pattern.

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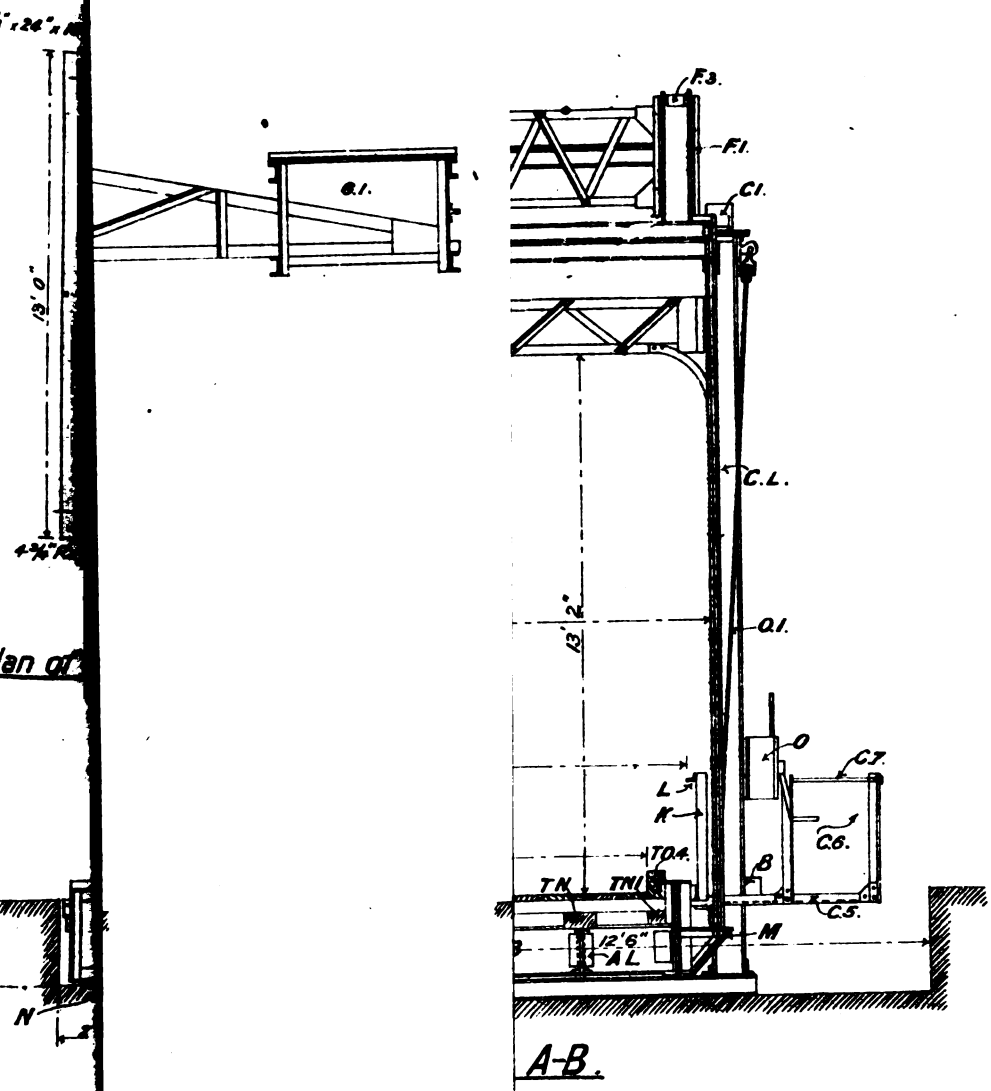
PLATE XI.

VIS BRIDGE - MA

RAL ARRANGEMENT.



A-B.

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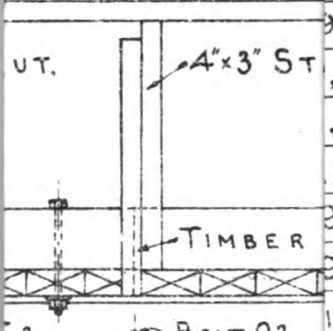
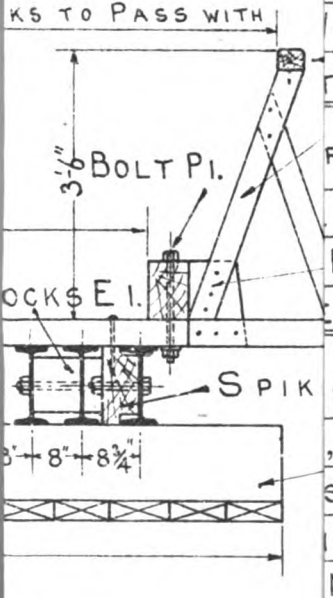
PAN TO CA



EVATION.



LIST FOR ONE SPAN.

RIPTION.	GROSS WT. T	C	Q	L
LBS. × 22'-0" R.S.J's	3	15	1	20
9" × 6" × 22'-0"		6	1	4
, 9" × 4" × 11'-0"	1	5	3	20
, 9" × 4" × 15'-6"		7	2	13
AIL, 12" × 6" × 22'-0"		8	1	22
9" × 9" × 7 5/8"		2	1	22
9" × 9" × 2 3/8"			1	1
I LS, STRUTS, ETC		5	0	14
ER FOR GUSSETS.			1	4
LTS {EACH WITH 1 NUT & 1 WASHER.				20
LTS WITH NUTS			1	21
LTS {EACH WITH 1 NUT & 1 WASHER.				9
3/8" S.a × 7" LONG				25
IRE NAILS				10
T OF 1 SPAN:-	6	12	3	9

FOR EACH CONTINUOUS SPAN.

ATES, 8" × 3/8" × 1'-2".		2	2	8
R.H. BOLT & NUT.			2	24
IGHT PER JOINT:-		3	1	4

E SET ¾ T BANKSEATS.

, 12" × 12" × 13½ 6"		10	1	13
S, 9" × 3" × 4'-3"		10	3	20
G, 9" × 3" × 13'-6".		5	3	4
NAILS.				10
F 1 SET BANKSEATS	1	7	0	19

ADDED TO ALL BOLTS & SPIKES.

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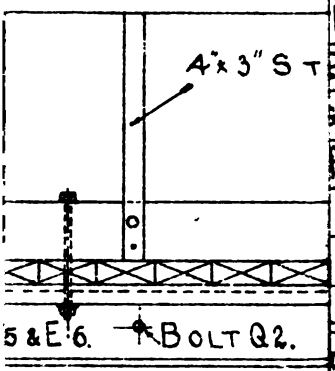
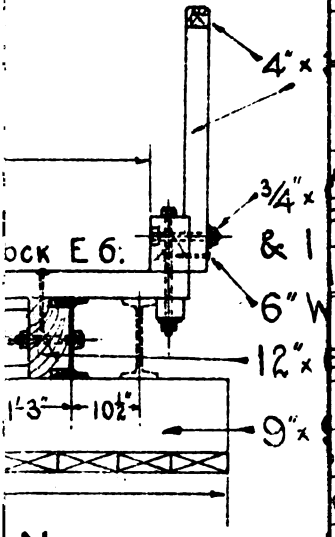
D.P/755/2.
(SUPERSEDES D.P/741/1,2&3)

D SPAN D.



E VATION.



N.

CRIPTION.	GROSS WT.			
	T	C	Q	L
LBS: x 22'-0" R.S.J.	1	17	2	24
9"x 6"x 22'-0"		6	1	4
, 9"x 4" x 11'-0"	1	11	1	9
RAIL, 12"x 6"x 22'-0"		8	1	22
9"x 9"x 8 5/8".			3	19
9"x 9"x 1'-8 5/8"		2	0	23
S. STANDARDS E.TC.		4	2	0
TS {EACH WITH 1 NUT & 1 WASHER.				25
TS -do- -do-				19
TS -do- -do-				9
S, EACH WITH 1 NUT.			1	15
3/8" Sq. x 7" LONG.				23
NAILS.				10
OF 1 SPAN:-	4	12	2	7

OR EACH CONTINUOUS SPAN.

ATES, 8"x 3/8"x 1'-2".		1	1	4
R.H. BOLT & NUT.			1	12
GHT PER JOINT:-		1	2	16

E SET 3/4 T. BANKSEATS.

9"x 9"x 12'-0".		5	0	16
, 9"x 3" x 3'-0".		6	3	12
G, 9"x 3"x 12'-0".		5	0	16
NAILS.				10
1 SET BANKSEATS		17	0	26

DDED TO ALL BOLTS & SPIKES.

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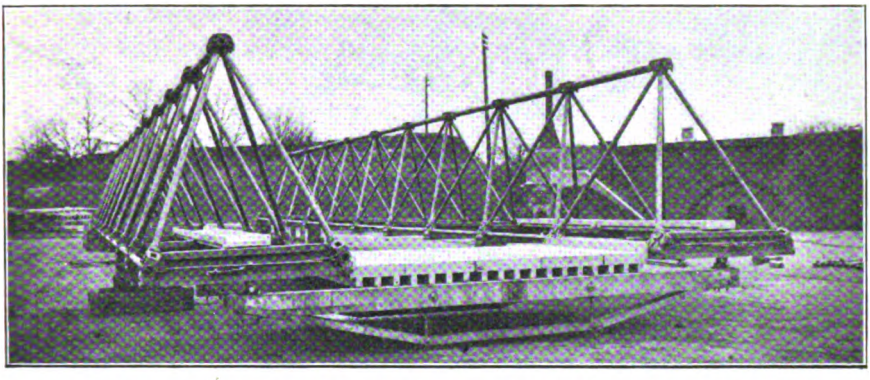
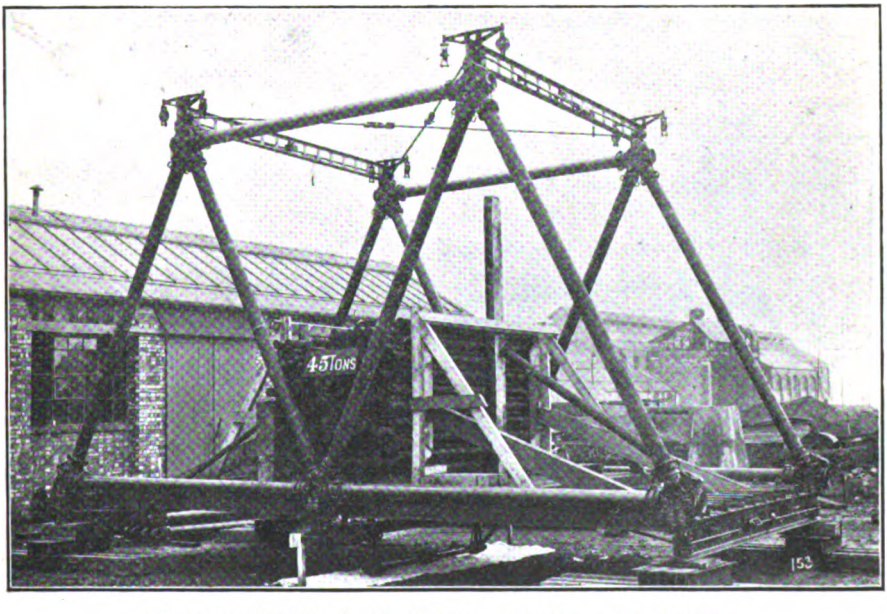


Photograph XI.—Inglis Bridge.



Photograph XII.—Inglis Bridge : Rectangular Pattern.

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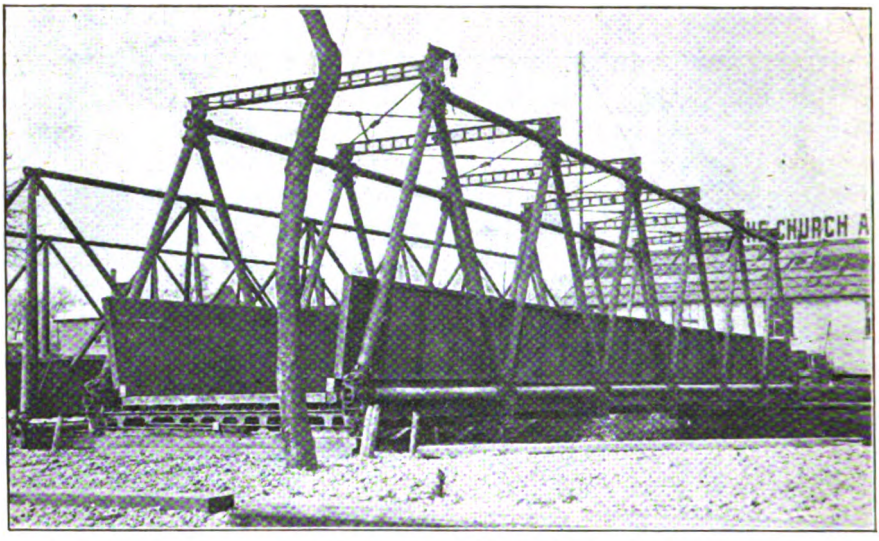
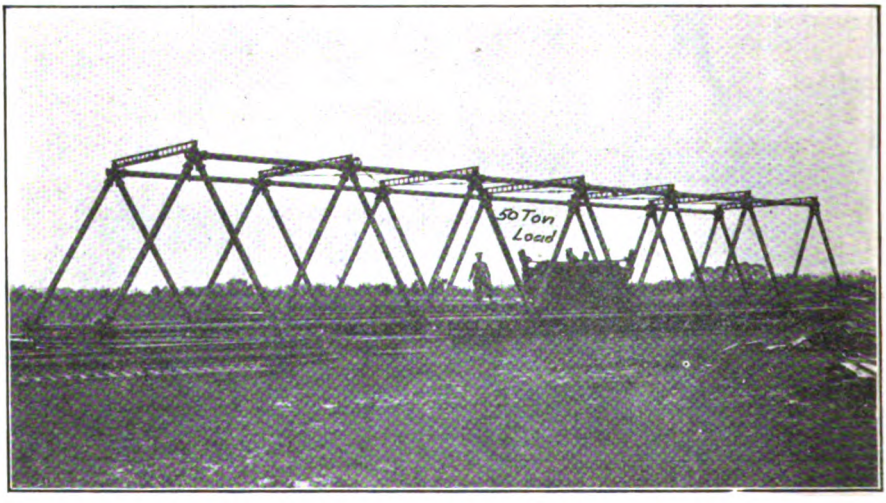


Photograph XIII.—Inglis Bridge: Rectangular Type.
Inglis Bridge, Heavy Type, in background.



Photograph XIV.—Inglis Bridge: Strengthened Type.

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operations for which the design was made, these bridges were never used, and the barges were dismantled during the summer of 1918.

Sankey Bridge.—The piers of this floating bridge were formed by the standard pontoons, and the roadway was carried by stock rolled steel joists. The bridge was designed to carry loads up to 14-ton caterpillars. It was made use of several times during the advance in the autumn of 1918, and was found quite satisfactory for sluggish currents, for which clear waterway between pontoon piers need not be considerable.

The three types are illustrated on *Plates* XIV. to XVII.

Types B and C require steel joists and certain other special stores.

Type D requires nothing except pontoon equipment and stores, to be obtained from any Corps dump.

Bridge B will carry all B loads, and with proper precautions, is capable of taking A loads in emergency.

Bridge C will carry the heavy commercial lorry, and bridge D loaded 3-ton lorries. (See *Photographs* XVI. and XVII.)

6. *Bridging Depôts and Stores.—Base Depôts.*—Reference has been made in Para. 2 to the formation of a heavy bridging depôt at Havre.

As the size of the forces increased a general division of supply was made between the northern and southern lines of communication.

The Northern Armies were based on Calais and Boulogne, the Southern ones on Havre and Rouen.

A second heavy bridging base depôt was therefore formed early in 1917, at Les Attaques, near Calais.

The D.E.S. automatically took over both these depôts in the summer of 1918.

Barge Depôts.—As soon as steel spans began to arrive in France arrangements were started to provide each army with a heavy bridging depôt. These were at first designed to be barge depôts for canal traffic and were formed mainly to provide mobile storage of bridging plant at a time when the wholesale destruction of canals seemed unlikely; we had then full power of movement by canal up to Armentieres, beyond Bethune and on the Somme.

Each army was provided with a fleet of 280-ton barges consisting of one fully equipped workshop barge; two store depôt barges, each carrying two 60 ft. spans, two 30 ft. spans, and two 13 ft. spans, with launching gear, roadway, and erection stores; two timber depôt barges, each carrying pile drivers and 30 ft. lattice steel derricks, in addition to timber; two turn-table barges.

By the end of 1915 three fleets were completed, and a fourth nearly so.

Early in 1917 these barge depôts were dismantled, and the barges handed over to the Inland Water Transport Department. This was primarily due to the urgent demand for transport barges by the

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I.W.T., but by this time it was realised that canal transport was not likely to prove feasible for bridging material during an advance.

As a subsidiary matter the barges were fitted for use as floating bridges; details are given in para. 5; they were intended for use as such behind our lines, and might have proved of great value in the first half of 1918 if they had not been already dismantled.

Army Bridging Store Depôts.—The absence of canals over a large portion of the front at the beginning of 1917 necessitated the formation of bridging store depôts in army areas.

These were first started on a small scale by the Fourth Army when the Germans withdrew across the Somme after blocking the canal, and by the Third Army for the battle of Arras.

More information will be found on this subject in the introduction to Chapter 3.

From the very first the great importance of the supply of all accessory stores required in the execution of heavy bridging was fully realised, and a complete list for each type of bridge was carefully worked out and published in the original *Memo on Construction and Repair of Road Bridges*. Of these stores the larger and more expensive were kept only at the base park, whilst the lighter stores, timber, etc., were kept in the army barge depôts. The original lists remained unaltered until the spring of 1917, when they were revised, and published on a special form.

Early in 1918 a revised list of stores was got out for an army bridging store depôt, the stores being divided into sets which were calculated to be sufficient for the erection of any three bridges; three such sets forming a complete army bridge store depôt. (See *Plate* XVIII., Copy of Form H.B., 23A.).

Considerable difficulty was always found both in the storing and the transport of these stores, as they were supplied from various sources.

The ideal was that every bridge sent up from the base, for erection by the army during operations, should be accompanied by all the stores required in the erection of the bridge. This was not practicable, and would also have been wasteful of transport, as many of the stores already existed in army and corps advanced parks.

To the end of the war no completely satisfactory solution had been arrived at, and each army made the arrangements that seemed best for the provision of such stores.

Special Bridging Stores.—In addition to the stock spans stored, full new details were worked out of suitable cribs, piles and trestles for bridges across the normal waterways. Materials for such were kept both at the base parks, and at the army barge depôts. *Plate* XIX. gives details of a standard trestle as adapted for use with R.S.J. field spans.

Steel Cube Piers.—Mild steel cubes 3 ft. high were stocked at the

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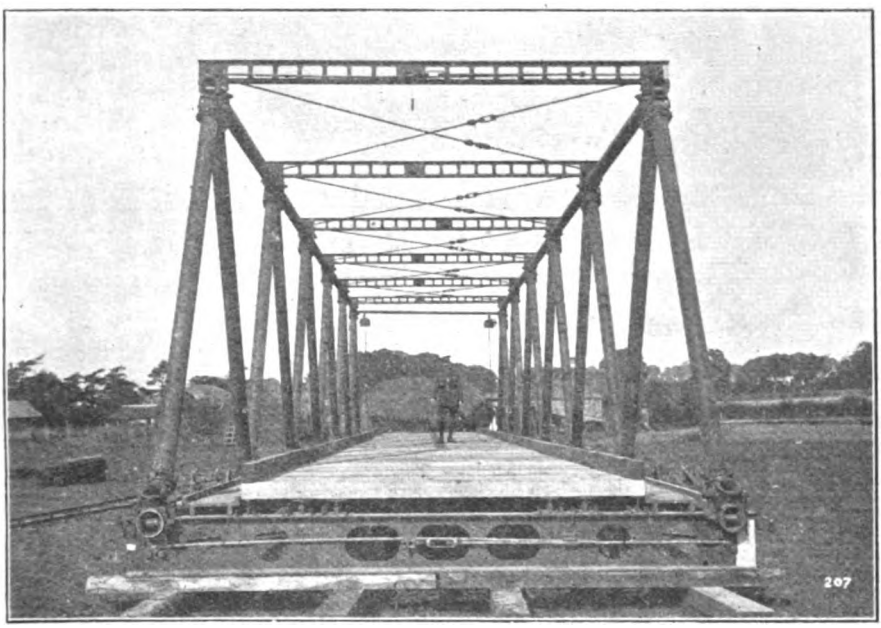

Photograph XV.—Inglis Bridge: Strengthened Type.

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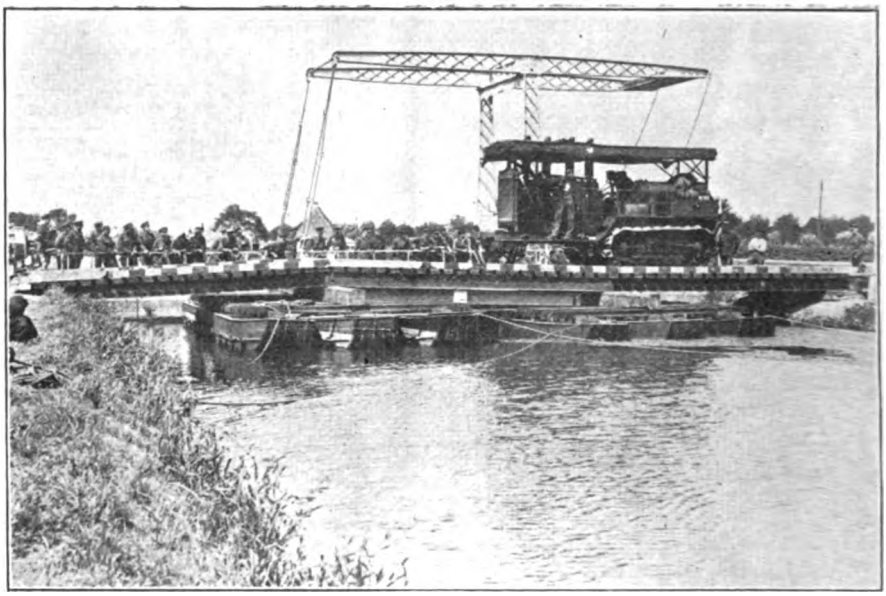
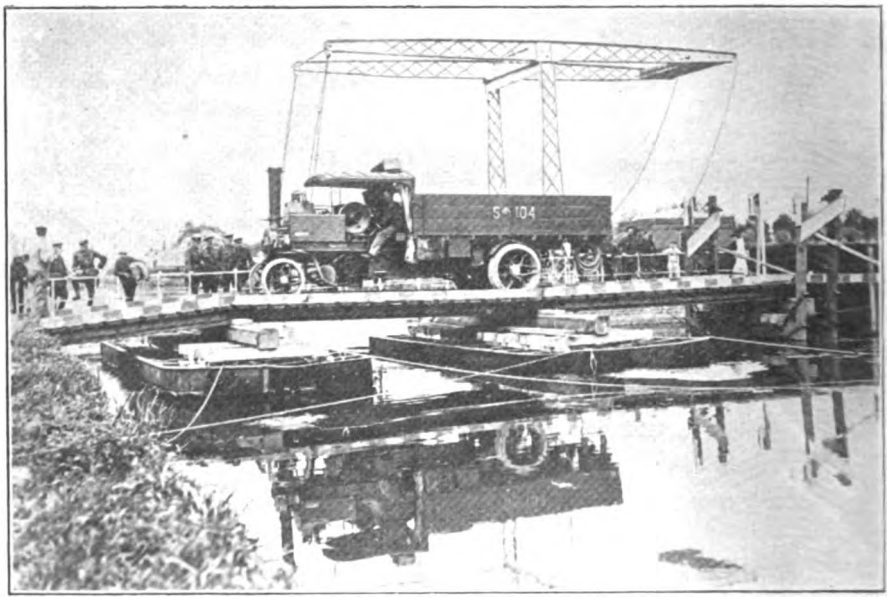


Photograph XVI.—Bridge "B."
Showing Caterpillar—Weight 14 Tons.



Photograph XVII.—Bridge "C."
Showing Loaded Foden Lorry—Total Weight 11 Tons.

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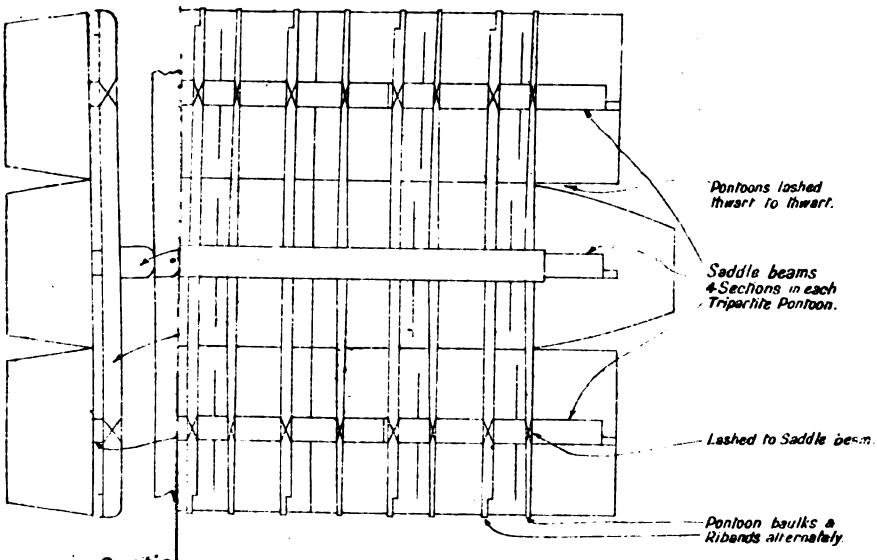
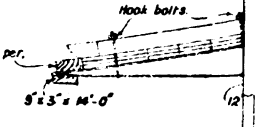
PLATE XIV.

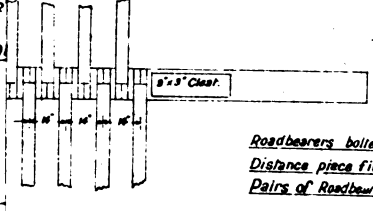

Pontoons lashed thwart to thwart.
Saddle beams 4 Sections in each Tripartite Pontoon.
Lashed to Saddle beam.
Pontoon baulks & Ribands alternately

Transverse Sectio

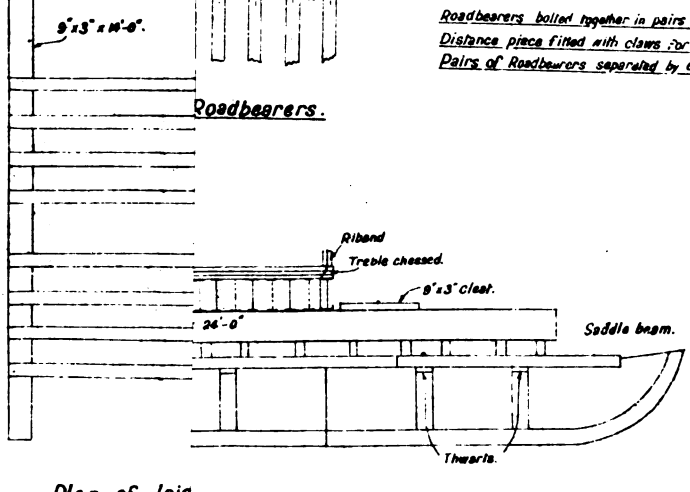
Roadbearers.



Sho



Roadbearers bolted together in pairs with distance piece.
Distance piece fitted with claws for 12"x12" saddle.
Pairs of Roadbearers separated by 6" spikes.



Plan of Jois tion.

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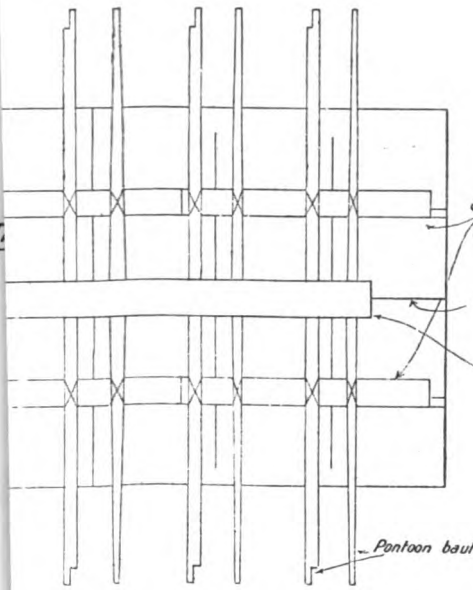
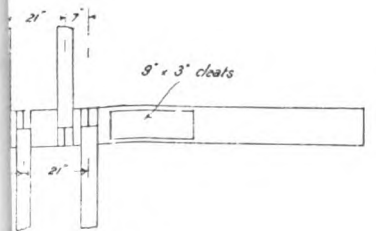
PLATE XV.


Saddle beams, 4 sections in each tripartite pontoon
Pontoons lashed thwart to thwart
12" x 12" x 24'.0".
Pontoon baulks or ribands

DBEARERS.



Roadbearers bolted together in pairs, with distance piece.
Distance piece fitted with claws for 12" x 12" saddle.
Pairs of Roadbearers separated by 6" spikes.

ADBEARERS.

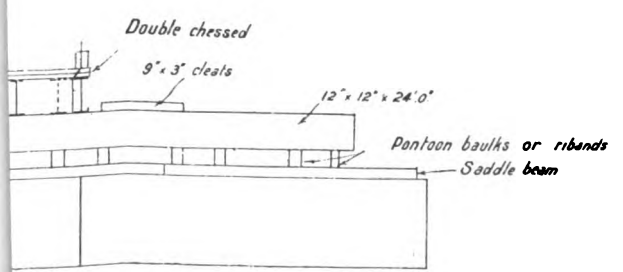


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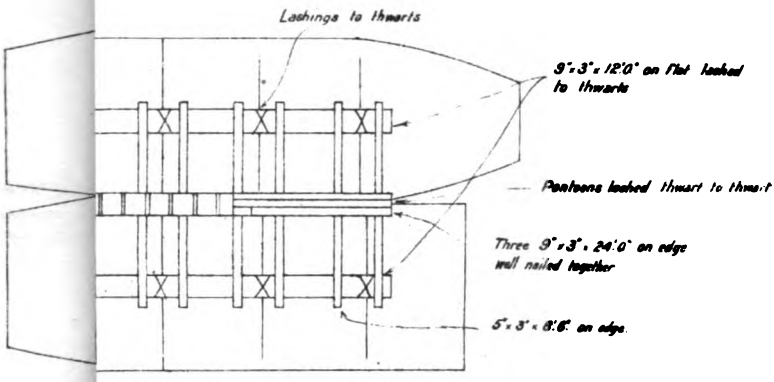
PLATE XVI.

RANSVERSE SECTION

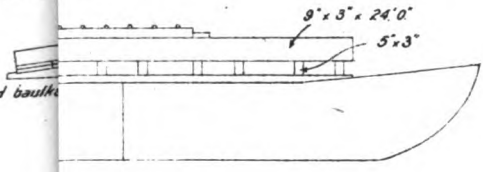

Lashings to thwarts
9"x3"x 12'0" on flat lashed to thwarts
Pontoons lashed thwart to thwart
Three 9"x3"x 24'0" on edge well nailed together
5"x3"x 8'6" on edge.

Superstructure
double chesse

clearness

With more than one pier, the rafts might consist alternately of
4 bow sections: 2 stern sections.
and 2 bow sections 4 stern sections

Improvised Riban e beam lashed to 9"x3"



ON

10 inside
Shore Baul

OF 9"x 3"

Drawn by F.E. Hayward, B.Sc., B.E.

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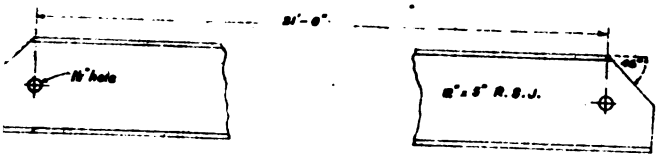
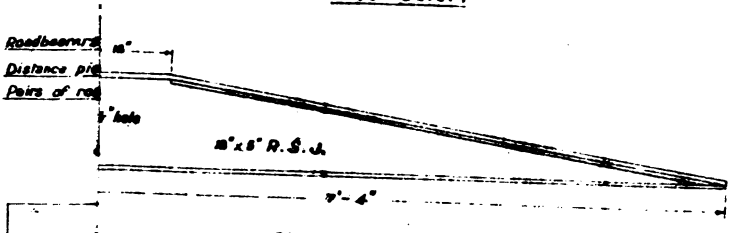
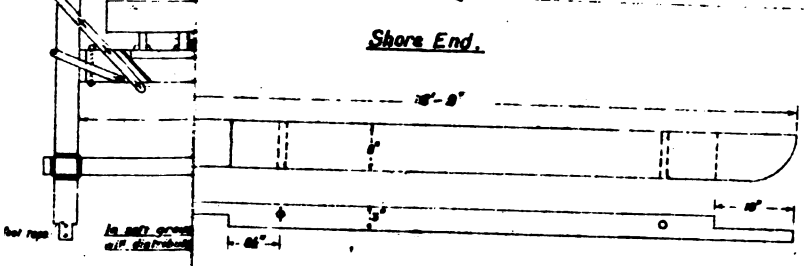
PLATE XVII.



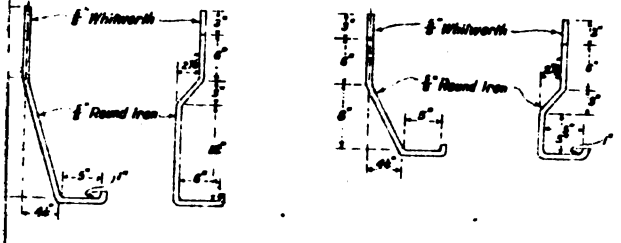
Steel Joist.



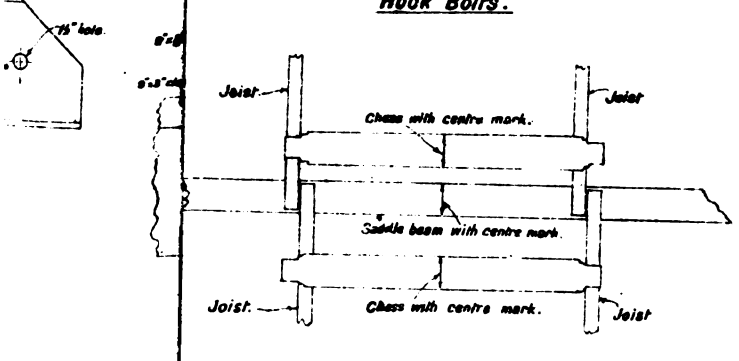
Shore End.



Riband.



Hook Bolts.



Showing method of spacing joists by using chase as template.

ARMY PRINTING

Drawn by L. Shadgett Cpl. R.E.

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SHEET AND ST

1 Item.	2 "Engineer" or "Ordnance" Supply.	3 DESCRIPTION.	4 Base Park Bridging Depot, each consisting of	5 Army Bridging Depot of three Sections, each consisting of	6 Total Stock authorised.	7 Present Stock.	8 Quantities demanded.
			One Depot.	One Section.			
130	O	Nails, [illegible] grade "B":—					
131	O	,, [illegible] in. × ½ in., lbs.		28			
132	O	Nailpu[illegible] ¾ in., lbs.		28			
133	E	Oil, lu[illegible]fferential, 6 ton	2				
134	O	,, lin[illegible] ,, 2 ton	13	1			
135	E	Oxy-ac[illegible] ,, 15 cwt.	.	3			
136	O	Packin[illegible]easuring metallic woven, 100 ft.		4			
137	O	,, [illegible]easuring, steel, 100 ft. ..		2			
		[illegible]40 gall. casks		3			
138		Paint, lead					
139	E	Pevee [illegible]horages, 12 in. or over dia-					
140	E	Piledri[illegible]r, 24 ft. long		6			
		15 [illegible]horages, 12 in. or over dia-					
141	E	Piledri[illegible]r, 16 ft. long		4			
		and[illegible] 8 in., F.R.	8000				
142	E	Pile ri[illegible] 12 in., F.R.	2000	100			
143	E	,, [illegible] 12 in., F.R.	12000	800			
144	E	Pile sh[illegible] 6 in., F.R.	5000	400			
145	O	Pliers, [illegible] 10 in., F.R.	17000	400			
		cut[illegible] 5 in., F.R.	2000	250			
146	O	Posts, [illegible]9 in., F.R.	12000	400			
147	O	Pump[illegible]6 in., F.R.	2000	100			

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PLATE XIX

SE WITH R SPANS

rial List

ion	Section	Length
	10"x10"	11'-9"
s	10"x10"	11'-11"
es	9"x4"	21'-0"
	12"x10"	18'-0"
	12"x10"	14'-0"
	9"x3"	3'-6"
	8"x8"	2'-0"
	3/4"	20"
	3/4"	16"
	4"x4"x1/4"	
s	3/4"	24"
s	7/8"	20"
al	7/8"	10"
		6"

els 8"x8"x 2'-0" long
other size greater,
suit height required.

3/4"x 16" Bolt
with 2-4"x4"x1/4"
Washers

6"

1'-0"

DETAIL OF

OF CORE

alved for 12T Axle Load Bridge

ARD FIELD SPANS FOR
INE TRANSPORT

In Tank Bridg
R.S.J's should alm
corbels as shown
junction of 2 Sp
by overlapping
would be spread
the load would
tributed over a
number of Jois
In 17T 12T ar
Transport Bridge
may be lapped
In this case, care
taken to sp
Bridge long

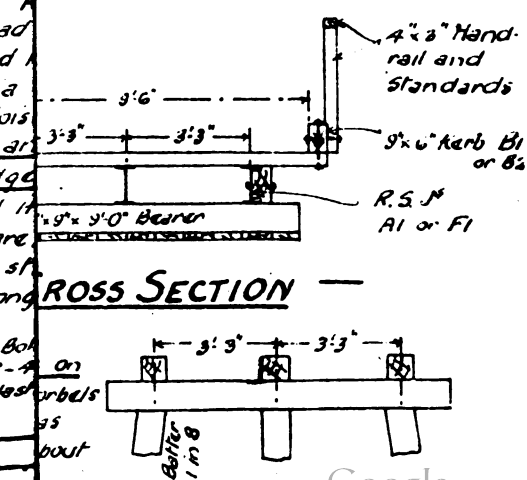
Spikes

3/4"x 16" Bol
with 2-4
x 1/4" Was

2'-4 1/8"

12T BRIDGE

on
orbels
gs
bout



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base depôts for the erection of cube piers. This type is economical and light, and will stand a weight of 40 tons on each cube. They were very suitable for quick erection on land, but difficult to place in water.

Pile Drivers.—The standard hand pile driver was 24 ft. high, with 15-cwt. monkey. Although this was extensively used, no two units ever agreed as to its merits or demerits, and demands for a mechanical driver were general. It was noticeable that when mechanical drivers were supplied, units generally went back in a short time to the hand machines.

Petrol Pile Driver.—A standard petrol driven pile driver winch was provided, but although received at first with acclamation, was actually very seldom used. This may have been due to the absence of special heavy bridging units with *personnel* trained in the use of such appliances.

Such machines required a permanent crew, and were seldom made full use of if transferred from one unit to another without *personnel* accustomed to work them.

They must also be provided with spare parts and repair materials.

For 9-in. to 12-in. piles a petrol driven driver with a 15-cwt. monkey and a 24-ft. frame would appear to be generally suitable.

Steam Pile Drivers.—Eight steam pile drivers with monkeys from 20 to 30 cwt. were obtained, but were never actually used, and in only a few cases were there sufficient piles to be driven at one site to warrant the erection of such a driver. Similar pile drivers erected on rafts were used very successfully by the Inland Water Transport, but in their case they always had a large number of piles to drive at a given place, also all the work was carried out on navigable waterways.

One very heavy steam pile driver with an overhang of 30 ft., capable of driving two piles simultaneously, was obtained for the construction of viaducts across a waterway or flooded country, but was never actually used.

Air Compressor Plant.—During the final advance it was often found possible to salve damaged girders of the destroyed bridges, and to re-erect them *in situ*. For this type of work and also in drilling existing girders for reinforcement to carry tanks, a portable air compressor plant was found most valuable. Each plant weighed about three tons, and could be conveniently mounted on and worked from a 3-ton lorry, or a 7-ton trailer. One of these plants, with a complete set of tools, was being supplied to each army, but did not arrive in time to be of much use.

Storekeeping and Issuing.—One of the most technical, and certainly among the most important branches of bridging organisation was the care and issue of stores. As the amount of bridging material increased, a very great strain was brought on the *personnel* at the

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base, whilst formations had to make use of any skilled *personnel* that they could find, and which was at any time liable to be moved.

The earliest practical bridging operations, *i.e.*, the crossing of the Somme in March, 1917, made very clear the primary importance of skilled organisation in the supply of material. This was improvised, and during the intensive operations of 1918, and in spite of the greatest difficulties, there is hardly a case on record of any breakdown in the organisation.

One of the great difficulties that had to be faced during the greater part of the war was the storage and care of the steadily increasing accumulation of bridging material at the bases.

During 1916 there was a feeling in some quarters that shipping and ports were being blocked by the large quantities of material for which the actual need was still open to question.

As a result, the Director of Fortifications and Works came to France as President of a Committee, which investigated the whole question of R.E. stores. This committee entirely concurred in the demands that had been made and were being made, and the supply of bridging and other stores proceeded unchecked.

When the great final advance began there were many anxious moments, during which it seemed impossible to keep pace with the requirements of heavy bridging, but although at times reserves of all stock spans fell to a dangerous point, there was never any actual failure to supply what was required.

7. *Special Bridging Staff and Units.*—It has been already mentioned that for the greater part of the war there was no special bridging *personnel.* In 1915 a qualified officer was attached to the office of the Engineer-in-Chief as acting Bridging Officer.

He made reconnaissances of various routes behind our lines and calculation of the strength of the bridges on these routes, with a view to the passage of heavy guns or tanks.

He also worked on the classification and collation of bridging stores, and also on details of the application of various stock spans to certain canal and river crossings. This officer remained about a year.

In March, 1917, another specially qualified officer came to G.H.Q. and remained as bridging officer until the end of the war. His first work was the design of the new bridge to replace the 85-ft. A span.

Subsequently he worked out details of all the various rolled steel joist bridges, as well as the revised lists of stores, and various technical details connected with the erection of the various spans. In addition to these duties a lot of practical work was carried out in the field, including at times the direct superintendence of the erection and dismantling of bridges, as well as regular liaison with the Bridging Officers of Armies and Corps. This officer came on the authorised staff of the Engineer-in-Chief in July, 1917.

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During 1918 the work increased enormously, and two officers, Instructors at the Bridging School, were brought into G.H.Q. to assist. During times of special stress one or more of these officers were attached to the Chief Engineer of the army most busily employed, to give assistance in the heavy bridging work. It was very noticeable that in such cases Chief Engineers almost invariably chose to put these officers in charge of the supply and issuing of bridging spans and stores, rather than employ them in superintendence of actual bridging operations.

The training given at the bridging school had by this time been sufficient to ensure a fairly general acquaintance with the erection of all stock spans among the R.E. field units, but the preparatory work in assembling both bridge sections and stores needed very special technical qualifications. This is dealt with more fully in Chapter II.

In every operation which entails bridging on any considerable scale, both Army and Corps concerned found it essential to detail a special officer for this work alone.

It was not until the autumn of 1918, when the increased scale of field engineers on the staff of C.E.'s of Armies and Corps came in, that a permanent bridging officer could be appointed in each formation. The training of complete units was always a problem of the greatest difficulty, and was never really solved.

The advantages to be gained if such training had been possible were forcibly illustrated by the very high degree of skill attained by one Army Troops company that had the opportunity of practical training. (See para. 3, Chapter II.)

When the final advance began, and it was obvious that heavy bridging was becoming one of the most important duties, if not the most important, of the Royal Engineers, a scheme was worked out in the Engineer-in-Chief's office for the formation of special bridging companies. These companies were to be formed from a certain number of existing Army Troops companies with special equipment and transport. The idea was that one such company should be allotted to the Chief Engineer of each army, and would be divisible into small sections, which would form the nucleus round which other R.E. units could work on the erection of bridges.

This proposal was not generally concurred in by Chief Engineers of armies, and was finally dropped.

8. *Transport of Stock Spans.*—The most useful transport which could normally be obtained by Chief Engineers of armies were the pontoon wagons of the M.T. Pontoon Parks. These vehicles would carry practically any of the standard sections—the only ones that gave difficulty were those of the 85-ft. span, and long rolled steel joists, or long timbers for piles.

After 1916 the Engineer-in-Chief had at his disposal twelve 5-ton

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Berna lorries, and twelve 7-ton trailers. The Berna lorry has a frame with top transom fitted behind the cab, and another frame carrying a roller and winch fitted on the rear of the chassis. They will take girders, long timber or piles up to 32 ft. in length. The 7-ton trailer hauled by a F.W.D. lorry was the most suitable type of all vehicles for heavy bridging material. They could be loaded up to 6 tons, and could be fitted with planks so that small stores as well as large sections could be carried. Twelve additional trailers were on order when hostilities ceased.

Other types of transport that were sometimes used are :—

(1) 5-ton steam Foden—
This was suitable for all loads up to 24 ft. in length.

(2) 5-ton Clayton steam lorries—
These are similar to the Foden, but have shorter bodies. They will take loads up to 18 ft. in length.

(3) 3-ton petrol lorries—
These are suitable for all loads except for girders or girder sections over 20 ft in length.

(*To be continued*).

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THE 5th (FIELD) COMPANY, R.E., AT POLYGON WOOD, 11th NOVEMBER, 1914.

EXTRACT FROM REPORT OF C.R.E., 2ND DIVISION.

(*With Sketch Plan*).

AT about 9.30 a.m., on 11th November, 1914, the 5th (Field) Co., R.E., were in dug-outs in Polygon Wood, and a heavy shell-fire had been going on for some hours. Major Tyler was informed by the Brigade Headquarters that the Germans had broken through. Some twenty men, under Sergt. Lethbridge, were sent to the south side of Polygon Wood to the trenches there, and the rest of the sappers, with all the officers, went south into the open, and occupied a disused trench and a short length of hedge on the left rear of it. The latter was under Lieut. Gowlland, with Corpl. Curtis and six sappers, and a few men of the Connaught Rangers. Some Germans from the wood on the right enfiladed this trench, and the right flank was turned back by six or eight men under Corpl. Chambers. In signalling up more men to protect this flank, Lieut. Collins was killed. Sapper Farmfield at great risk to himself, lifted Lieut. Collins into the trench.

The men on the right flank were unable to hold on owing to smoke from a house in the wood, which the Germans had set on fire. The Company was therefore ordered to fall back along the trench to a new position.

The second position consisted of the hedge on the left rear of the first position. There was also a detached right flank, well thrown back, behind a slight rise in the ground, consisting of 15 R.E., under Lieut. Gowlland, and 20 to 30 infantry (Connaught Rangers, etc.) This flank fired into the wood on the right and enfiladed a party of Germans who had started entrenching in rear of it. The Germans brought up a machine-gun in the wood to enfilade this detached right flank, and an officer of the Connaught Rangers called for a volunteer to cross to the main line, some 150 yards away, and ask for orders. No. 19541 Sapper T. Wilson offered to go, and, in spite of heavy machine-gun fire he got the message through, falling once on the way to avoid the machine-gun fire which followed him. He brought back an order to advance on the right of the line, joining on to the Oxfords, who were now advancing through the wood and driving the Germans back.

The whole line now advanced, shooting and bayoneting from

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90 to 100 of the enemy outside the wood, and the R.E. and some of the infantry took up a position in the original support trench, from the right of which a good fire was kept up into the retreating Germans. This line was occupied only for a few minutes. A further advance was made, chiefly by the R.E., and there seems to have been some lack of cohesion. Part under Lieut. Gowlland, and apparently under orders from within Polygon Wood, advanced half-left, and reached the edge of Polygon Wood, where they advanced along the H.L.I. trench, so as to bring a cross-fire in front of the rest of the advance. Corpl. Chambers, however, with three sappers, advanced half-right to Lieut. Renny-Tailyour's party. Part, under Lieut. Renny-Tailyour and a Connaught officer, went across the open turnip-field, and a third party, under Major Tyler and Lieut. Vibart, who was wounded in the wrist, along the communication trench. The Oxfords appear to have advanced some 200 yards to the right of this trench and to have stayed there.

After crossing the turnip field the men under Lieut. Renny-Tailyour converged towards the communication trench, and came under very heavy machine-gun fire from a farm on the right front. Corpl. Curtis and three men, who were in a shell-hole, got into the trench, and heard a message sent to Major Tyler to come and speak to an officer of the Leinster Regiment. Major Tyler went on with Corpl. Curtis and some R.E., telling them to keep their heads down. He himself must have shown his head over the parapet and was shot. The Leinster officer then ordered Corpl. Curtis with L.-Corpl. Jack and Sappers Farmfield, Keelog, Vyse, Hope and Stewart, to hold the end of the trench, and they did so under heavy fire for half an hour.

Meanwhile, Lieut. Renny-Tailyour's party came under heavy machine-gun fire, and tried to get into the communication trench. Two were killed and three wounded. An infantry officer, who was bringing on some men of the Connaughts, got into the trench, and when Lieut. Renny-Tailyour tried to follow he was shot. Corpl. Chambers, who was within six feet of him, and the three sappers with him (Sappers Harlow, Wroe and Moriarty) were unable to follow owing to machine-gun fire, and, hearing Lieut. Gowlland calling them from the wood, they wriggled back in that direction. Sapper Wroe got up at great risk and helped a wounded man of the Connaughts into the wood. The man fell once but Sapper Wroe again got him up.

Meantime, the six men under Corpl. Curtis were under shrapnel fire from the rear and had to retire. Sappers Farmfield and Kellog carried Major Tyler's body down the communication trench until stopped by infantry holding the trench, where they had to leave him.

The advance to capture the original position having failed, presumably for want of support, the retirement of the R.E. took place about 4.30 p.m., by two routes, *i.e.*, from the communication and

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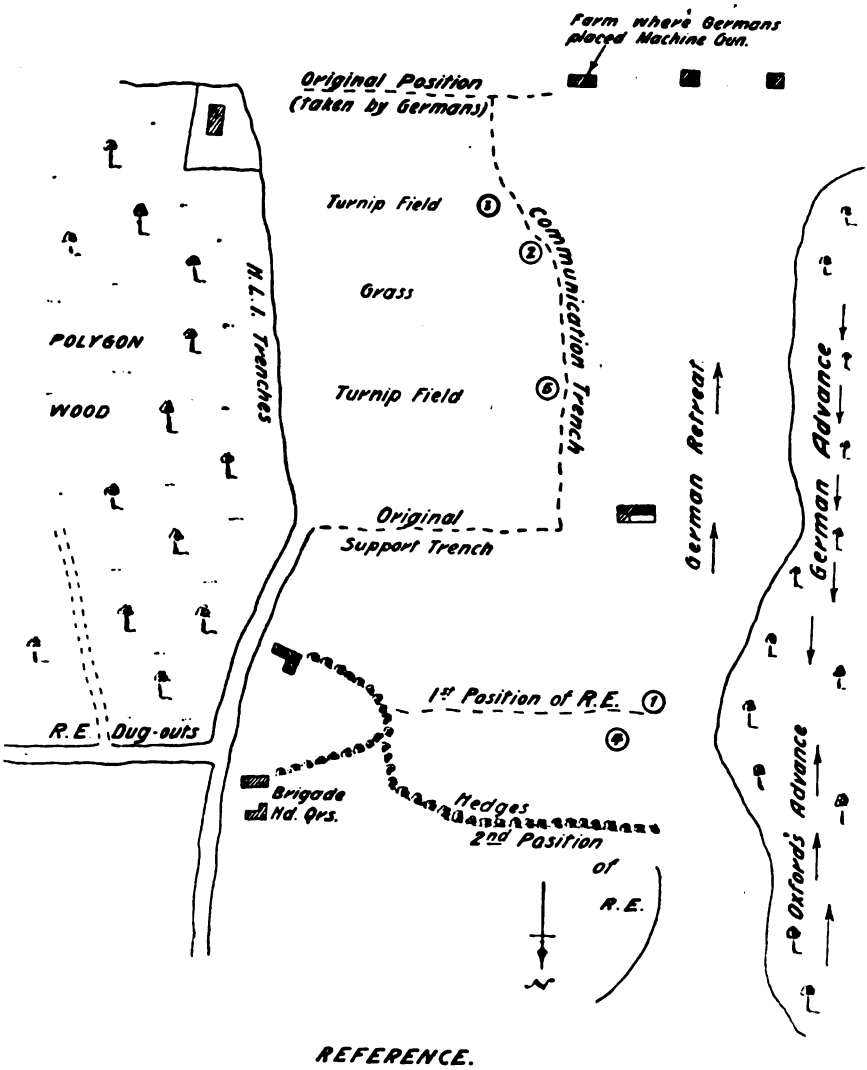
DIAGRAM OF ACTION OF 5TH FIELD COY. R.E.
11: 11: 1914.



REFERENCE.

① Lt. Collins shot.
② Maj. Tyler shot.
③ Lt. Renny Tailyour shot.
④ Approx. position of Lt. Collins' grave.
⑤ Probable position of Maj. Tyler's grave.

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support trenches, and from Polygon Wood. The latter was also under shrapnel fire from the rear, but in both cases reference was made to Brigade Headquarters before retirement. Sapper Wilson again took this message for the Captain of the Connaughts, under fire, from the support trench.

On the same date, at 9.30 a.m , when the company was called up from its bivouac to assist in driving back the Germans, who had broken through, five sappers (W. Vye, J. Carman, G. Hope, A. Duckett, and J. Stuart), who were employed as cooks, were left behind. These men went and joined a French battery in the vicinity, and stayed with it at the request of the O.C., who spoke English. A French gunner was shot, and the O.C. asked the sappers if they would find out if there were any Germans in a house 300 or 400 yards away. The sappers advanced in skirmishing order, under the leadership of Sapper Vye, under fire. When within 100 yards of the house, three sappers were left to maintain a covering fire, while Sappers Vye and Duckett advanced on the house, which was found to contain five Germans, three of whom fled and two were made prisoners. The prisoners were handed over to the French battery. The sappers then rejoined a part of their company under 2nd Lieut. Vibart, and took part in the final counter-attack on the enemy, in which Sapper Duckett was wounded.

ORDER OF BATTLE OF ROYAL ENGINEER UNITS IN ALL THEATRES ON NOVEMBER 11TH, 1918.

THE following amendments to the lists published on pages 50—67 of *R.E. Journal* for August, 1919, have been notified :—

(*a*). On pages 50 and 51 :—

After "Mesopotamia" *insert* new theatre "North Russia" and *add* against "Field Companies" under that heading :—

402nd Field Co.
548th Field Co.

(*b*). On pages 53 and 54 :—

Against "Fortress Companies" under the heading "Foreign Garrison" *insert* :—

27th Bermuda
28th Malta
36th Sierra Leone
40th Hong Kong
41st Singapore
43rd Mauritius
44th Jamaica
45th Gibraltar
48th Ceylon (since renumbered 31st)

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
R.E. (T.F.) *Divisional Field Cos.* *Highland Div. H.Q.*			
No. 1 Field Co.	1/1 400th Field Co., 51st Div., France.	2/1 403*rd Field Co.* Disbanded when 64th Div. was broken up. 20/Engrs./5334.	3/1 merged into Scottish Group Reserve Field Co. 408th. See Note against 3rd line below.
„ 2 „	1/2 401st Field Co , 51st Div., France.	2/2 404*th Field Co.* 51st Div., France.	3/2 405th Field Co. Disbanded. when 64th Div. was broken up 20/Engrs./5334. See note against 3rd line of 2/3 Co. as regards the 4/2 Co.
„ 3 „ ... ... (Not pre-war.)	1/3 *Not* pre-war. .402nd Field Co. Disbanded when 64th Div. was broken up.	2/3 merged into Scottish Group Reserve Field Cos. A.C.I. 2420 of 1916. See 3rd line.	The 3/1, 4/2 and 2/3 Highland and 2/1 Renfrew formed the 408th Highland Reserve Field Co. of the Scottish Group, which on reorganization of R.E. Reserve Battns. was absorbed into 6th Reserve Battn. R.E. 20/Engrs./5214 (A.G.7.B.) of 12. 1. 18. The 6th R.B. now reduced to Cadre. 91/Engrs./1311.
Signal Co. (Highland Divl. Signal Co.)	1/1 now 51st (Highland) Divl. Signal Co.	2/1 *Signal Co.* was broken up when the 64th Div. was disbanded. 20/Engrs./5334.	3/1 *Signal Co.* merged into Signal Service Training Centre. See A.C.I. 1438 of 1916 and 615 of 1917.
Lowland Div. H.Q.			
No. 1 Field Co.	1/1st 409th Field Co., 1st Div., France.	2/1 412th Field Co., 52nd Div., France.	414th Field Co. (3/1) } Ireland Remains of 65th Div.
„ 2 „	1/2nd 410th Field Co., 52nd Div., France.	2/2 413th Field Co., 52nd Div., France.	415th Field Co. (3/2) } Ireland Remains of 65th Div.
		The 4/1, 4/2, 2/3 Lowland and the 2/1 City of Edinburgh Field Cos. formed the 418th Lowland Reserve Field Co. (Scottish Group) and later the 6th Reserve Battn., R.E. See Note against 3rd line of Highland R.E.	
„ 3 „ ... ... (Not pre-war.)	1/3 *Not pre-war.* 411th Field Co., 1st Army, France. (Went to France as a unit of the re-mobilized 72nd Div.).	Amalgamated with Scottish Group Reserve Field Cos. 408 and 418th, which on the reorganization of Royal Engineer Reserve units in January, 1918, were absorbed into 6th Reserve Battn. R.E. 20/Engrs./5214 (A.G.7), dated 12. 1. 18. The 6th Reserve Battn., R.E., is now being closed down. 91/Engrs./1311.	

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.—*Cont.*

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Signal Co. (Lowland Divl. Signal Co.)	1/1 now 52nd (Lowland) Divl. Signal Co.	2/1 was the 65th Divl. Signal Co., Ireland, but on the break-up of 65th Div., some of the *personnel* went into the Signal Service Training Centre and some were retained for the Special Signal Co. for Ireland. It cannot be said, however, that the Special Signal Co. for Ireland is the 2nd line unit which should be considered as disbanded. 3/1 was merged into the S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.	
West Lancashire. H.Q.			
No. 1 Field Co.	1/1st 419th Field Co., 55th Div., France.	2/1 422nd Field Co., 55th Div., France.	The 3/1, 3/2 and 2/3 became the 426th W. Lancs. Reserve Field Co. of the Western Group Reserve Field Cos., of which group 300 went to 4th Reserve Battn., Deganwy, and remainder to Royal Monmouth Reserve Battn., R.E., W.O. letter 20/Engrs./5214 (A.G.7.B.) d. 12. 1. 18. The two Reserve Battns. R.E. are being reduced. 91/Engrs./1311 (A.G.7.B.).
,, 2 ,, ...	1/2nd 420th Field Co. was in 42nd (E. Lancs.) Div. Now in Army Troops, Salonika.	2/2 423rd Field Co., 55th Div., France.	
,, 3 ,, ...	1/3rd *Not* pre-war. 421st Field Co., 57th Div., France.	2/3 Amalgamated with Reserve Field Co. (426th) Field Co.	
Signal Co. (W. Lancs. Divl. Signal Co.)	1/1 55th Divl. Signal Co.	2/1 57th Div. Signal Co., France.	3/1 merged into S.S.T.C. See A.C.I.'s 1438/1916 and 615 of 1917.

Note.—The 55th (W. Lancs.) Div. had its own (territorial) units, but the 57th (W. Lancs.) Div. was composed of 1/3 (421st) W. Lancs., 1/3 and 2/3 (502nd and 505th) Wessex Field Cos., and 2/1 Wessex (57th Divl.) Signal Co.

East Lancashire. H.Q.			
No. 1 Field Co.	1/1 427th Field Co., 42nd Div., France.	2/1 430th Field Co., 66th Div.	The 3/1, 3/2 and 3/3 E. Lancs. Field Cos. formed the 435th E. Lancs. Reserve Field Co., Western Group, as to disbandment of which see Note against 3rd line, West Lancs. R.E.
,, 2 ,, ...	1/2 428th Field Co., 42nd Div., France.	2/2 431st Field Co., 66th Div.	
,, 3 ,, (*Not* pre-war.)	1/3 *Not* pre-war. 429th Field Co., 42nd Div., France.	2/3 432nd Field Co., 66th Div.	
Signal Co. (East Lancs. Divl. Signal Co.).	1/1 42nd (E. Lancs.) Divl. Signal Co.	2/1 66th Divl. Signal Co.	3/1 merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.

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Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Welsh Div. H.Q.			
Cheshire Field Co.	1/1 438th Field Co., 3rd Div., France.	2/1 439th Field Co., 74th Div., France.	3/1 440th Field Co. disbanded when 68th Div. was broken up. 4/1 merged into 445th (Welsh) Reserve Field Co. with 3/1 (Welsh) and 3/1 Glamorgan Field Cos., and formed part of Western Command Group Reserve Field Cos. The Western Group was reorganized. See note against 3rd line of W. Lancs. R.E.
Welsh Field Co.	1/1 436th Field Co., 53rd Div., Egypt.	2/1 437th Field Co., 53rd Div., Egypt.	3/1 (Welsh) merged into 445th (Welsh) Reserve Field Co. See 4/1 Cheshire above.
Glamorgan Field Co. (*Not* pre-war.)	1/1 *Not* pre-war. 441st Field Co. Disbanded when 68th Div. was broken up. 20/Engrs./5334.	2/1 442nd Field Co. disbanded when 68th Div. was broken up. 20/Engrs./5334. 2/1 550 *Field Co.* This unit was converted from the 2/1 Glamorgan Works Co. for the 72nd (Home Service) Div. until it was designated 550th (Field) Co. by 9/Engrs./7611 (A.G.7.) of 8. 1. 17 it was known as the 72nd Glamorgan Field Co. (Home Service). The 72nd (H.S.) Div. was broken up (114/Gen. No./5763). The 550th Co. was re-mobilized for the new 73rd Div. and went to France on 22. 6. 18. 2/2 551st *Field Co.* was converted from 2/2 Works Co. for the 72nd (Home Service) Div., which was disbanded (114/Gen. No./5763). The 551st Co. was disbanded 3. 6. 18 (R.Q. Returns/273 A.G.7.b.)	3/1 Glamorgan Field Co. was merged into the 445 (Welsh) Reserve Field Co. See note against 4/1 Cheshire Field Co. above.

Note.—It will be observed that there were two Field Cos. designated 2/1 Glamorgan and that there was no 1/2 Glamorgan *Field* Co. The 1/2 Glamorgan was an Army Troops Co., *i.e.*, the 557th. See Fortress Units.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.—*Cont.*

Present War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Signal Co. (Welsh Divl. Signal Co.).	1/1 53rd (Welsh) Divl. Signal Co.	2/1 68th (Welsh) Divl. Signal Co. Being disbanded since October, 1918. 20/Engrs./5334.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
Divisional Field Cos., R.E. (T.F.) Northumbrian Div. H.Q.			
No. 1 Field Co.	1/1 446th Field Co., 50th Div., France.	2/1 449th Field Co., 28th Div., Salonika.	3/1 451st Field Co., 15th (Indian) Div., Mesopotamia. See also note below.
,, 2 ,, ...	1/2 447th Field Co., 50th Div., France.	2/2 450th Field Co., 15th (Indian) Div., Mesopotamia.	See Note below.
,, 3 ,, ... (Not pre-war)	1/3 not pre-war 448th Field Co., 15th (Indian) Div., Mesopotamia.	2/3 merged into 454th (Northumbrian) Reserve Field Co. (Northern Group), which was subsequently merged into R.E. Reserve Battns. 20/Engrs./5214. See 3rd line.	No 3/3 Field Co. formed.
		Note.—The 4/1, 3/2 and 2/3 became the 454th Reserve Field Co., Northern Group. The Northern Group was merged into the R.E. Reserve Battns. 600 to R. Anglesey Reserve Battn., remainder to Royal Monmouth Reserve Battn. 20/Engrs./5214 of 12. 1. 18. The two latter Reserve Battns. are being reduced. 91/Engrs./1311.	
Signal Co. (Northumbrian Divl. Signal Co.).	1/1 50th Div. Signal Co., France.	2/1 Signal Co. was in the 63rd Northumbrian Div., but the Royal Naval Div. (which had its own Signal Co.) was re-designated 63rd Div., so the 2/1 Northumbrian Signal Co., was broken up.	3/1 Signal Co. was merged into the Signal Service Training Centre. See A.C.I.'s 1438 of 1916 and 615 of 1917.

(To be continued).

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CORRESPONDENCE.

ACOUSTIC PHENOMENA OF THE WAR.

To the Editor, R.E. JOURNAL.

SIR,

In the September issue of the *R.E. Journal* it is stated that throughout the summer of 1916 the rumbling of gun fire was heard in Sussex. I should like to place on record the fact that it was continuously audible in my garden at Rochester, but there was no rumbling. The reports, though faint, were separate, distinct, and clear, averaging from 35 to over 50 rounds a minute. It gave the impression of a distant *feu de joie*, very slow and irregular. Its monotony became wearisome. I assumed that we only heard the heavies. The garden front of my house faces roughly E.S.E., and the ground in that direction is open.

It was understood at the time, from tests in France, that the main factor in the transmission of sound from great distances is the state and direction of the air in the upper regions above the ground wind, the waves descending here and there where favourable conditions exist. Unfortunately they must have been unduly favourable in my case.

Yours faithfully,

H. D'ARCH BRETON, *Colonel*,

Guildhall, Rochester, 8th September, 1919. *Mayor.*

[NOTE.—It will be seen from the conclusion of Colonel Sir E. Thackeray's review of the article in the *Rivista* that the writer of the article arrives at the same conclusion.—EDITOR, R.E.J.]

REVIEW.

MOLESWORTH'S POCKET-BOOK OF ENGINEERING FORMULÆ. 28th Edition. Price 10s.—(Spon & Co., 10, Haymarket, S.W.1.)

A new edition of this extremely useful pocket book has now been published—comprising 872 pages (index additional). It gives a great deal of new information, especially on the subjects of Steam, Boilers, Locomotives, Petrol Engines and Aerodynamics, the sections on which have been re-written and re-arranged. It is noted that the 1907 British Standard Specification for concrete is still referred to, though the latest specification came out in 1915. A short note on Reinforced Concrete is now inserted.

H.L.L.

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NOTICES OF MAGAZINES.

BULLETIN OF THE INSTITUTION OF MINING AND METALLURGY.

April, 1919.

The Work of the Miner on the Western Front, 1915—18.—By H. Standish Ball, M.Sc. (late Assistant Inspector of Mines, G.H.Q., France).—To give some idea of the exceptional value of this article to all readers of the Royal Engineers, it will suffice to reproduce the list of sub-heads:—

I. Formation of Companies.
II. Principles of Mine Warfare.
  (*a*) Geology.
  (*b*) Crater Formation.
  (*c*) Explosives.
  (*d*) Mining Tactics.
III. Mine Listening Instruments and their Application.
IV. Mine Rescue Work.
V. Mining Operations.
  (*a*) Somme Offensive, July, 1916.
  (*b*) Arras Offensive, April, 1917.
  (*c*) Messines Offensive, June, 1917.
  (*d*) Miscellaneous.
VI. German Offensive, March, 1918.
VII. Allied Offensive, August, 1918.
VIII. German Traps and Land Mines.
IX. Technical Training.

The article is lavishly illustrated, and some of the descriptions, especially in the case of sub-head III., "Mine Listening Instruments," and sub-head VIII., "German Traps and Mines," are given in considerable detail, in fact it is surprising how much information the writer has been able to include in the short space of a single lecture. That it is of engrossing interest throughout is a proof that it is by no means a barren list of official details. It bears ample testimony to the gallant and heroic actions of the tunnellers, which are well recognized in Field Marshal Sir Douglas Haig's Order of the Day:—"Their fighting spirit and technical efficiency has enhanced the reputation of the whole Corps of Royal Engineers and of the Engineers of the Overseas Forces." By the courtesy of the Institution of Mining and Metallurgy, sanction was given for the reproduction of this article in the *R.E. Journal*, but, on account of the pressure of other matter, it is regretted that this generous sanction cannot be taken advantage of. It should, however, be mentioned that copies of this article can be obtained at the offices of the Institution, 1, Finsbury Circus, London, E.C.2, at the price of five shillings.

F.E.G.S.

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MILITÄR WOCHENBLATT.

June (continued).

The translation of Lord French's "1914" is continued. Each number contains a summary of events in Poland calculated to show that the Poles are preparing to invade Germany, and a number of advertisements calling for volunteers for "freecorps," defence corps, and the regular army; the military spirit is not dead yet. There is also a review of the Press, with extracts from the English, French, and American papers which show any softening towards Germany.

No. 146.

How we lost the War.—The situation at the end of 1916 was critical; the battles at Verdun and of the Somme had cost very heavy losses and worn the troops engaged to the utmost limit, and yet it was necessary to send strong forces to Russia to meet the Brussilov offensive and to crush Rumania. The failure of Nivelle's offensive in May, 1917, the subsequent mutiny of French troops, and the German retirement to the Hindenburg Line saved the situation. It is asserted that 40 French divisions mutinied, and that on one day alone 200 men of one regiment were shot by order of court-martial. During the summer the trouble was overcome by the French, but was beginning to be felt in the German Army. There was a regular planned boring and nibbling at the pillars of our strength, the sense of duty and discipline of our men. Letters from home narrating conditions there worked on the soldiers' feelings; there was an increase of marauding and desertion, unwillingness to fight, and mistrust of leaders. Much of the trouble at home was due to profiteers (*Kriegsgewinnler*), and to many of the requirements of the State having got into the hands of business men who with their narrow-minded selfish training could not work unselfishly for a great cause. The worship of the golden calf even affected official classes.

The Ministry of War and the D.O.B.—There is apparently some difference of opinion between the Ministry of War and the Union of German officers as to the rights and functions of the Union.

There is significant conservatism in *Answers to Correspondents.* Retired Lieut.-General is informed:—"Your *Excellency's* note has been passed on to Mittler & Co." So the old titles of respect go on.

No. 147.

How we lost the War (continued).—The Army of 1917 was not to be compared with that of 1914, there was still, however, a good leaven, which had its effect in battle. On the other hand there were plenty of units which provided a breeding ground for the bacteria of unrest. The first actual trouble arose in the Navy. The success of the winter of 1917—18 had a great effect, and even workmen in the Army blamed the strikers at home; unfortunately, the revival of a good spirit was choked by the arrival in the West of troops from Russia, impregnated with the revolutionary tone, and of recruits contaminated by home influences.

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In the spring of 1918 the Germans had superiority of numbers in France, units were full up and the men rested. The writer ascribes the failure to push on at Amiens to lack of motor transport due to want of raw materials. When in June the men found the enemy merely driven back and not annihilated, the "will to victory" disappeared. The third offensive, towards Rheims, completely failed, partly on account of bad luck, but partly also through whole bodies of troops failing in their duty. For instance, north of Soissons a whole division left the field almost without fighting; as a good division went forward to restore the situation the men of the former shouted "You damned strike breakers, you are going to block the hole that we have just made." The writer, however, claims that the army was still strong enough to cause the Allies heavy loss, although they had then numerical superiority. He makes the absurd statement that in Champagne the French-Americans would not attack when a German machine-gun appeared, and that French officers had to drive their men on by threatening them with pistols. Finally, he asserts that the revolution was the "stab in the back" which finished the war.

Roll of Honour of *No.* 13 *Infantry Regiment.*—172 officers killed (this is the largest total yet noticed).

No. 148.

Military Competitions.—Notice of sports to be held at Potsdam, 14th—16th August:—Swimming, gymnastics, cycling, riding, team racing, etc. This is quite a new feature of German Army life.

Roll of Honour of *No.* 10 *Pioneer Battalion* (*Field Companies*).—32 officers killed.

No. 149.

A Word in the Last Hour.—By Colonel von Livonius.—An article full of hate and revenge. He calls on clergy of all confessions to preach "holy hate as a morally purifying and liberating power," and ends with a quotation from the poet Felix Dahn: "All Europe shall stand in flames when Germany goes down."

The Economic Position of Officers.—Demands compensation for officers compulsorily placed on half-pay.

The Old Pension Scale.—Bitter complaints of its inadequacy. A captain after 20 years' service is only entitled to 1,141 marks per annum, majors after 25 years, to 1,361 marks, etc.

Infantry Regiment No. 130.—A notice with regard to the disbandment of this Lorraine Regiment.

Can Remounts be Trained quicker than in the Former Regulation Manner.—Mentions among other things that the German horses were very soft and could not stand exposure, and generally condemns the official methods.

Roll of Honour of Infantry Regiment No. 82.—92 officers killed.

Posts open to Officers.—A list of four only.

Advertisements.—There are more than the usual number of calls for volunteers for frontier guards, old and new army. One for the West

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Prussian Frontier begins: "For the protection of the liberty of our sore pressed East Mark, the 35th Division and the Volunteer Jäger Corps, Gieseler, calls on all students and true German sailors to unite as a defence against the mad and immoderate action of the Polish vultures."

No. 150.

How our Horses stood the War, by Major General von Poseck.—An article of interest. It ascribes the failure of the horses (given as one of the causes of the German collapse by the General Staff) to their being too much coddled in peace time. A number of instances are given of the cavalry being unable to move, *e.g.*, as early as the 11th August, 1914, von der Marwitz's Cavalry Corps had to halt for rest and good food; on the 2nd September, the 2nd Cavalry Division had to stop pursuit, as its horses were tired out. Richthofen's Cavalry Corps had to be given a rest day on the 8th August, on the 29th August the horses were incapable of a trot across country, etc., etc. No wonder the German cavalry accomplished so little.

Protest of the German Officers' Union against the Peace.

Co-operation of the Arms ensured by War Establishments.—A plea that artillery should form part of infantry regiments.

No. 151.

Generals for Signing the Peace Treaty.—Insinuates that no soldier will sign it.

Officers' Unions and the Defence Chamber (Wehrkammer).—The article endeavours to show that officers can belong to both—the Unions protect their personal interests; the so-called Defence Chamber is a political institution (nominally to guard the interests of the Army, practically to organize and train the nation for war independently of the War Ministry).

How our Horses stood the War (continued).—Contains a comparison of the true value of the various breeds of horses. It is claimed that the East Prussian horse was the best army horse, and advocates that a smaller horse should be bred.

Roll of Honour of Infantry Regiments No. 82.—87 officers killed; No. 77.—109; N. S. Foot Guards—66.

No. 152.

Appeal of the Officer Corps of the Prussian Army and Navy to the Queen of the Netherlands and the Netherlands States General.—This appeal that the ex-Kaiser shall not be handed over is printed in large type.

Regimental and other Unions of the Old Army.—An editorial appeal to found military unions to maintain remembrance of the honourable and glorious old units "never defeated by enemy arms," and to prepare for the future.

Hindenburg's Farewell.—This has already appeared in the British Press. He particularly thanks the "Volunteer formations that had held the watch on the Eastern frontier."

General Oberst von Moltke's Memoirs.—With reference to a notice in

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the Press that the younger von Moltke's memoirs will not be published, announces that the General Staff will shortly issue a pamphlet dealing with the causes of the war, covering the years 1911—14.

The French Deployment in 1914.—With reference to M. Engerand's book *Le secret de Charleroi*, the M.W.B. warns its readers against believing that the French were surprised by the Germans violating Belgian neutrality.

Rolls of Honour.—No. 17 Hussar Regiment, 24 officers killed; No. 67 Infantry Regiment (Magdeburg) and its machine-gun battery, 134 officers and more than 300 N.C.O.'s and 3,000 men killed; No. 55 Infantry Regiment (Westphalia), 110 officers killed.

July, 1919.

HISTORICAL.

The General Inspection of the Engineer and Pioneer Corps, Berlin, begs all officers of the Pioneer arm (*i.e.*, what we call field units) to write down anything of interest which they may have experienced and to send it to the Engineer Committee, Section 4, where documentary sources are also available.

The History of the Pioneers in the World War, which is being prepared by the Engineer Committee, will, it is hoped, be a memorial to the great services and heroism of the Pioneers.

Everybody who co-operates in the work will earn the special thanks of the Pioneer Corps.

J. E. EDMONDS.

REVUE MILITAIRE SUISSE.

No. 7.—July, 1919.

THE GERMAN AND FRENCH CAVALRIES IN THE GREAT WAR.

A further instalment of the article on the above subject by Colonel Poudret, begun in the number of the *Revue* for March last, appears in the number under notice, the text is accompanied by a number of sketch maps. The account of the German "push" which began on March 21st, 1919, is continued; the chief episodes which occurred between the 23rd and 30th *idem* are detailed.

The Germans succeeded in crossing the Somme below Ham on the 24th *idem* and on the following day Nesles fell into the enemy's hands in spite of the vigorous counter-attacks of the British infantry and cavalry. The 22nd Infantry Division forming part of Robillot's Command, however, succeeded in checking the enemy's advance from Nesles, and at the same time French cavalry, belonging to the same command, was pushed west to gain touch with the British troops. In the meantime the retirement caused a gap in the line between the British 18th and 19th Corps; the French 2nd Cuirassier Regiment was consequently rapidly

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moved to the neighbourhood of Chaulnes, to repair this break in the line, and came into action at Ingron, where it fought stubbornly.

On the 26th *idem*, the Germans gained the Roye-Noyon road and a gap was thus made in the French line near Lassigny. In consequence, the French 1st Cavalry Division made a night march, from the hard-fought fields of Noyon, and made good the breach in Robillot's right wing; this Division suffered severely in casualties in carrying out its task, but the men were not to be deterred by the heavy sacrifice which had to be made by them.

The situation on Robillot's centre was critical but some French Squadrons re-took Roye, in a dismounted action, from the Germans; unfortunately they were not able to retain their hold on this place. On the other hand, the 5th Cavalry Division managed to hold on in the Avre Sector between St. Aurin and l'Echelle-St. Aurin; touch with the British right wing was thus maintained. This cavalry was on the 26th *idem* transferred to Debeney's Army, which had just reached the Pierrepont Sector.

The 27th *idem* was a still more critical date. Pellé's Command, being strongly supported in a position favourable for defence, was able to maintain its line; Robillot, however, was not so well placed, and in consequence, had to retire. On this date the French 4th Cavalry Division, which had disentrained at Moreuil on the previous date, was able to act in support of the infantry N. of the Avre, in the direction of Erches. Unfortunately, the Germans had seized Guerbigny; in consequence this Division could not carry out the mission entrusted to it.

On the 28th *idem* was fought the Battle of Montdidier. Six additional German Divisions reinforced the 13 already in their line. The Germans were thus able to gain a footing on the plateau S. and W. of Montdidier. A part of the French Cavalry Division, however, re-took Monchel, Mesnil-St. George and Fontaine-sous-Montdidier at the point of the bayonet and restored the French line in this neighbourhood.

Fighting continued with varying success. Finally Robillot was able to establish himself on the line Cuvilly—Mortemer—Rollot; here the French 1st Cavalry Division held on tenaciously to the positions assigned to it. During this period, this Division had carefully kept its horses out of the fighting line and had engaged *exclusively in dismounted action*.

On the 30th *idem* the Germans made a great effort to break through along the whole front. It was already too late; reinforcements had arrived and Debeney had succeeded in reorganizing his Command in a position N. of Montdidier, the junction of the British and French Armies was fortunately still intact; in consequence Amiens had not been reached.

Of the troops that had proved a strong shield to the *heart of France* none had played a greater and more glorious part than the French cavalry. The Cavalry Divisions that had undergone the severe trials of this period showed how valuable can be the services which a modernized cavalry force, properly instructed and imbued with the right spirit, can render on the field of battle.

At the time that the Germans launched their Great Offensive in March,

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1918, the only part of their cavalry which remained mounted was that employed on the Eastern Front. To-day the German leaders must be regretting the mistake they made in retaining in the Ukraine and in Finland the whole of their cavalry.

A short account follows of the German " push " in Flanders in April, 1918 ; this was launched on April 9th on a 15-mile front between Mont Kemmel and La Bassée with 20 Divisions. The Portuguese troops were driven back and the British 1st Army forced to retire across the Lys.

The French G.H.Q. in consequence, ordered the 2nd Cavalry Corps (under Robillot) from Blangy to the region St. Omer-Steenwoorde. The last-named place was reached at 8 a.m. on April 15th. This was a remarkable performance under the circumstances prevailing—one of the Divisions of this Corps marched no less than 435 miles in 27 consecutive days.

The task assigned to the French 2nd Cavalry Corps was to fill the gap caused by the retirement of the Portuguese troops and to maintain touch with the British 1st and 2nd Corps. It constructed *point d'appuis* on the hillocks of Flanders on a line facing S. This Corps bore the brunt of the fighting on the 16th and 17th *idem* ; it was finally relieved by French infantry on the 21st *idem* and went into rest quarters.

Between the 25th and 29th *idem* the Germans made two desperate attacks on the line Mt. des Chats-Kemmel ; and the 2nd Cavalry Corps was therefore sent into the line again at Mt. Kemmel. It proved a strong support to the troops which had been tried by severe fighting and for 20 days held on to the positions confided to its charge, in spite of the severe bombardment and the furious assaults of the enemy.

On May 27th, the Germans began their third great " push," this time on the line Pinon Forest—Rheims ; they succeeded in crossing the Aisne and reached Chateau Thierry and the borders of the Forest covering Paris. The French 1st Cavalry Division met the shock between Fismes and Dormans ; whilst the 5th Cavalry Division operated in conjunction with the 20th Infantry Division, the 1st Cavalry Division was employed in filling up gaps in the line and in supporting the infantry generally. Eventually the Germans were brought to a halt for a second time on the Marne, and a new front was created by the Allies and was held until July 15th.

The French 2nd Cavalry Corps was again called upon to play a decisive *rôle* in these operations. On May 28th it was stationed in the region of Aumale and received orders on that day to move southwards. By forced marches it reached the line Betz—Mareuil-sur-Ourcq on the evening of the 31st *idem*, and it subsequently took part, in support of the infantry, in the fighting in the neighbourhood of Dammard.

At the date of the German " push " in July, 1918, the French 1st Cavalry Corps (Féraud) was in rear of Gouraud's Army, in the region of Chalons. When the German Artillery opened fire against the front Prunay Massiges on the night of July 14th—15th, the 5th Division of this Corps was ordered to the region of La Veuve, but the circumstances having altered the move was cancelled. The German attack having failed, this Corps was no longer wanted in the neighbourhood of Chalons

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and it was consequently moved, so as to be in a position to support the troops on the Marne.

On the evening of the 16th *idem*, the Germans were on the line Nesle —le Repons—Montvoisin. The G.O.C. 2nd Cavalry Corps issued orders for a concentric attack on Oeuilly to be launched at 11 a.m. next day, the cavalry under Moinville being assigned to the sector extending from the River Marne on the right to La Cense-Carée (exclusive) on the left. The attack began at the hour named, the artillery coming into action as arranged. It was not, however, till 8.30 p.m. on the 18th *idem* that the French Cavalry succeeded in capturing Montvoisin; the loss of Montvoisin rendered the position of the Germans, who were S. of the Marne, extremely precarious.

During the night of July 18th—19th, the 1st Cavalry Corps was, for tactical purposes, placed under the G.O.C. French 9th Army. Orders were now given for an attack on the heights on the S. bank of the Marne to begin at 8 a.m. on the 19th *idem*, the 5th Cavalry Division was directed to cover the right of the infantry attack in the Marne Valley. Towards evening of the 19th *idem* this Division succeeded in establishing a hold on the ground between Oeuilly and the Marne, S. of l'Echelle. During the night of July 19th—20th the Germans recrossed to the N. of the Marne. The task allotted to the 1st Cavalry Corps in this sector was at an end; it had played a conspicuous part in saving Epernay.

The use to which the cavalry was put in the operations connected with the capture of Montvoisin exhibits a true appreciation on the part of the superior commanders of the art of handling this arm; it shows how well the lessons which had been taught in relation to the employment of cavalry on the modern battlefield had been learnt.—(*To be continued*).

Permanent Fortifications in the Great War.

(*Western Front, August—October*, 1914).

Colonel Grosselin, the author of the original article, points out in an introductory section, that the true value of permanent fortifications was not always appreciated by the public during the Great War. This probably was due to the fact that a fortress which was considered impregnable fell in the short space of 12 days.

In a succeeding section definitions are provided of the terms field, semi-permanent and permanent fortifications. Explanations are also given of the prominent features of the several types of fortification, and the various stages in the development of these types is traced historically from the time of Vauban down to the present day.

The aim and object of fortifications are next discussed. An extract from Napoleon's *Notes* on the defence of Italy, written at Valladolid on January 14th, 1809, is given wherein he states briefly that the advantage one hopes to obtain from the use of fortified lines is "*To gain time.*" The four short statements in which the Great Corsican gave his views as to the circumstances under which permanent fortifications should be utilized are also reproduced in the original article.

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Brief notes explain the successful use made of fortifications, in 52 B.C. at Alesia, by Vercingetorix, and in 1799 A.D. at Acre (Palestine) by the Turks, *to gain time*. In the first case the defence works at Alesia gave the Gauls time to raise and organize an army of 240,000 infantry and 80,000 cavalry; and, in the second case the result was, as Napoleon himself admitted, that the defence works at Acre alone prevented the Great Consul from reaching India and proclaiming himself "Emperor of the East."

In a fourth section, the author of the original article calls attention to the the fact that, in all ages, a military commander who desired to seize a fortified place has always carefully weighed the *effort* that would have to be expended by his troops to accomplish the task proposed to be set them; and when he had finally arrived at a decision on the point he set to work to make the most complete preparations from the technical point of view to effect his purpose. In order to give some idea of the *effort* that is required under the conditions of modern war, Colonel Grosselin briefly examines some of the important situations on the Western Front in 1914, in which fortified places played a part. He considers first the defence of Liège (5th—17th August). Liège with its 25,000 men held up the Germans for 13 days, inflicting serious loss on them, estimated by the besiegers at 42,000 men, which gives some measure of the German *effort* against this place. The defence of Namur (19th—25th August) is dealt with next. The Belgian 4th Division and the detachment of French troops, which had taken part in the defence of this place, withdrew from this region on the 23rd August. The experience at Liège made the Germans more cautious and they brought heavy guns, including four Austrian 12 in. howitzers and one 16·5 in. howitzer. The German *effort* at this point is represented in part by the expenditure of 97,000 rounds, weighing some 7,710 tons and requiring 25 trains of 30 wagons each for their conveyance. The defence of Maubeuge (25th August to 8th September) is the last of the fortresses dealt with in this number of the *Revue*. The attack on Maubeuge was entrusted to the German 7th (Reserve) Army Corps and a Cavalry Brigade; a Division (probably belonging to the 7th (Active) Army Corps) was in support and a Siege Corps was also detailed to take part in the attack on this French fortress. Maubeuge held up 60,000 German troops for 15 days, who were thus unable to march to the Marne.

The siege train employed by the Germans comprised, *inter alia*, 12·5 in. and 16·5 in. pieces and also the Austrian Automobile Battery of 12 in. howitzers. The casualties suffered by the French garrison amounted, during the attack, to 5,000 men, the remainder were taken prisoners on the fall of the fortress. The Germans admit that they lost 12,000 men.—(*To be continued*).

INCREASE OF PAY AND INDISCIPLINE.

Major de Vallière, the author of the original article, expresses the opinion that of all the measures adopted during the past few months to improve the position of the Swiss soldier, for not one of them was there so little justification as that relating to the increases granted in the soldier's

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pay ; such a step was bound to create grave difficulties. By admitting the principle that the pay of a soldier should be equal to the wages of a labourer, the road has been opened wide, it is pointed out, to all sorts of claims and to political agitation in the army. The pay of a Swiss soldier has, by stages, been raised from 80 centimes to 8 frs. 50 cent. per *diem*.

Everybody agrees, says Major de Vallière, that it was necessary to improve the material comfort of the soldier and his family : there were many ways of doing this other than by the increase of pay. It would have been preferable to increase the scale of *rations*, to provide better *quarters* and to give *aid to soldiers' families*. The high pay is in the majority of cases of no real benefit to the soldier or his family, it finds its way into the pockets of the inn-keepers.

The effect of granting increases of pay has been to make the " question of pay " a subject for politico-military controversy to be exploited by agitators. The principal mistake consists in comparing the pay of the *citizen soldier* with the remuneration of the *professional soldier* and the wages of the labourer. It is quite right, says Major de Vallières, to give a high rate of remuneration to the volunteers who keep guard on Switzerland's frontiers and to those who devote their life-time to soldiering. The pay of the *citizen soldier* has never been considered anything but an indemnity to enable him to make good the minor wear and tear of his equipment. The confusion of ideas which has resulted from the Federal Council acceding to popular clamour on the question of the *citizen soldiers'* pay is one which, it is expected, will lead to considerable trouble in Switzerland in connection with the maintenance of discipline in the army.

Notes and News.

Switzerland.—Regret is expressed that Colonel Wildbolz, who has been in command of the 2nd Army Corps, has, for family reasons, been obliged to retire from the Swiss Army. The vacancy caused by this retirement has been filled by the promotion of Colonel Steinbuch, commanding the 5th Division.

Criticisms are directed against the " Directives " now being issued by the new Federal Military Department to the Instructional Staff responsible for the training of recruits. It is suggested that these " Directives " should be addressed to the medical officers in charge of recruiting and not to the Instructional Staff.

There are already indications that the Swiss Military Authorities will look westward and not northwards for the model on which the Federal Army of the future is to be organized and trained. Parties of Swiss officers have recently been touring the battlefields of France and were received officially in France by a high officer of the General Staff. There has also been a visit of a private nature to Verdun, arranged by one of the Officers' Societies ; other private visits are to follow.

Portugal.—The terms of the Peace Treaty are briefly reviewed by a special correspondent, who lays emphasis on the fact that the most recent Treaty of Versailles, unlike former treaties which have ushered in

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Peace, contains clauses the object of which is not exclusively to regulate the relations between the conquerors and the conquered, but also to endow the whole human race with a new Law with a view to inaugurating cordial relationship between the peoples of the Universe by compulsion, if necessary. Napoleon's treaties, it is pointed out, were framed in the interests of a dynasty, Bismarck's in the interest of a military autocracy whereas the latest treaty is the first which can be truly said to have been framed in the name of Liberty and Democracy—its foundation is not laid on the doctrine that Might is Right, it attempts to provide protection for the Small Powers.

Portugal has spent much of her treasure in the prosecution of the Great War and a feeling exists in the country that unless Germany is made to contribute towards the financial expenditure imposed upon the Portuguese people, the country will be ruined. The hope is expressed that the Great Powers will see justice done in this matter.

The number of the *Revue* under notice concludes with a list of books received for review.

W. A. J. O'MEARA.

RIVISTA DI ARTIGLIERIA E GENIO.

May, 1919.

AUDITORY ZONES AND ZONES OF SILENCE.

(*Concluded*).

Another acoustic phenomenon which calls for special attention during these years of war, is the so-called *zone of silence*. Observations show that intense sounds, such as those produced by explosion, are not always regularly propagated, but there occurs frequently an auditory zone, a zone of silence in which the explosions are not heard, and beyond this a second zone of audition.

Now, for some time before the present war, the existence of a zone of silence was noticed in different circumstances. Some examples of this are given by Professor Munro in his work entitled: *Zones of Silence in Sound Areas from Explosions*, published in the American review already quoted. During the battle of Perryville the sound of the first cannon shots was heard at a distance of about 11 km., while General Buell and his staff, who were at a much less distance from the battle-field were not aware of the cannonading which lasted from five to six hours. This anomaly is attributed to the topography of the district and the direction of the wind. In an explosion of about nine tons of powder that happened at Winchester station in Kentucky in 1884, the sound of the explosion was noticed at a distance of beyond 24 km., while the Chief Engineer of the railway and other persons who were at a distance of only 40 m. from the point where the explosion took place, and who were on the platform of a wagon, only heard a slight noise. While the windows

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of the houses were broken at a distance of a kilometre from the place of the explosion, these spectators were not aware of any effect of the concussion of the air. These facts, which seem scarcely credible, were reported by scientific men and confirmed by Professor Munro in the review *Nature*.

The existence of a zone of silence which separates two distinct zones of hearing is stated to be proved in twenty explosions that occurred before the war, of which two were caused by artillery fire, four by dynamite and gunpowder explosions, and the others by volcanic eruptions in Japan. It was generally reported that the normal zone of direct audition extended to about 100 km., and that there frequently occurred another abnormal zone of audition at a distance of 160 km., which extended to about 230 km.: and that between the two zones of audition there was a zone of silence of about 60 km.

Eleven eruptions of the volcano Asamagana in Central Japan, 1909—1913, allowed of observations on the phenomena of a zone of silence; in the greater number of these cases it was decided that the zones of silence were of less dimensions than those of audition, and were grouped in an approximately symmetrical manner around the area of the fall of the cinders. The final result was of a very elongated and narrow form, and developed approximately in the direction of the upper currents of the air that traversed the clouds of smoke of the volcano, a direction which oscillated between north-east and south-west.

Of other explosions which presented phenomena of zones of silence there may be mentioned that of Hayle (Cornwall) in 1904, of Forde (Westphalia) in 1903, of the Jungfrau railway in 1908, of Wiener Neustadt in 1912, with external zones of audition at the greatest distances of 144, 179, 179 and 298 km. Another quite recent example is the very violent explosion which happened in London on the 19th January, 1917. The interior zone of audition, with the very exceptional form of an L, extended to a distance varying from 19 to 104 km.; the intermediate zone of silence had dimensions varying from 26 to 86 km., and the greatest distance of its exterior limit from the point of explosion was about 96 km.; the exterior zone of audition was situated with a longitudinal axis towards the north of about 210 km. and transverse axis of 88 km.

There being no doubt as to the existence of a zone of silence how is this phenomenon to be explained?

Some have desired to found an explanation in the transmission of sound through the earth; if it can be supposed that the sound is heard over a particular geological formation, and that after a certain space covered by other formations, it is transmitted through a vein to a distant observer, while in the intermediary formations the sound was not heard.

Munroe cites some examples which seem to confute this hypothesis; and Esclangon observes that the phenomenon of a zone of silence happens when the sound is noticed not only on the ground but also in the atmosphere at great heights, such as in the case of firing against aircraft.

It would seem then that perhaps the geological nature of the soil may be excluded as a cause of the phenomenon, and Esclangon proposes an

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explanation of a more general character. It is known that the atmosphere is the seat of important movements which vary according to meteorological conditions; the wind changes frequently in velocity and direction according to the height of the strata from the ground. He therefore deduces that given certain meteorological conditions due to movements of masses of the air, the sonorous rays may be affected by these conditions.

To show a practical case:—Above a stratum of calm air there may be found another stratum animated by a velocity that increases according to its height from the ground; the sonorous rays starting from the origin of the sound and directed upwards meet this wind zone and are bent downwards and directed towards the ground. This is especially the case in the zone situated at about 13,000 m. from the ground, due to special circulation of masses of air independent of the movements of the lower atmosphere.

The extension of the zone of silence and the conditions of audition depend upon atmospheric conditions, on the velocity of the wind, and the depth of the atmospheric stratum in which the wind blows, etc. Together with these conditions there is another cause for the phenomenon, viz., the higher temperature near the ground, a cause well placed in view by Schaffers, Davidson, and in Japan, where the zone of silence is ascertained to be regular during the warmer months of the year.

In the pages of the *Meteorologische Zeitschrift* many cases are cited of important strategical events being decided by the sound of cannon. But it is necessary to eliminate all possible causes of error in order to obviate deception. It should now be opportune in a time of peace to undertake with rigorous scientific criticism a series of numerous trials to ascertain in different localities, by day and night, and under various meteorological conditions, etc., the existence and the laws of sound. To terrestrial observation should be added those made in the air, now so much facilitated by the means of aerial exploration.

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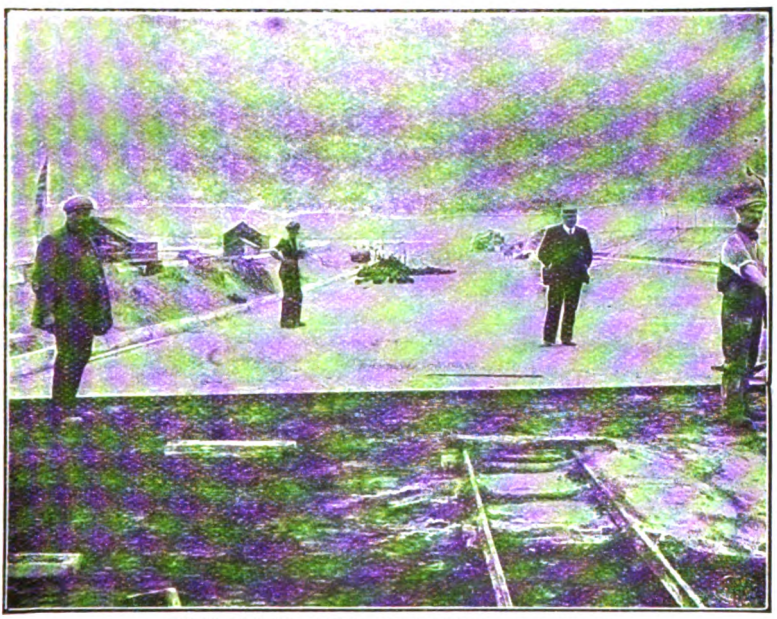

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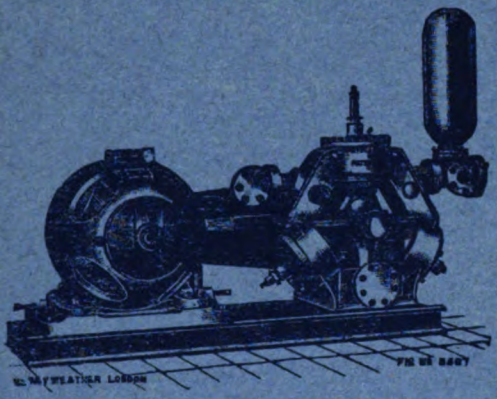

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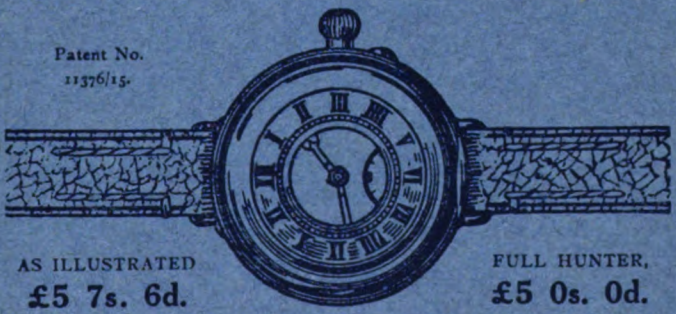

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WATER SUPPLY OF TROOPS IN THE FIELD.

By BRIG.-GENERAL R. P. T. HAWKSLEY, C.M.G., D.S.O.,
CHIEF ENGINEER, 21ST CORPS.

Water Supply for troops in the Field divides itself into three categories :—

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(*b*) Tactical, or in preparation for concentrations or offensives.
(*c*) When on the move.

The two former categories merge into one another, and the requirements for (*b*) should, as far as possible, be foreseen in making the provisions necessary for (*a*).

2. The allowance per head is :—per man—1 gallon per day ; per horse or mule—10 gallons per day; per camel—20 gallons every third day, and these amounts should be calculated for in (*b*) and (*c*).

The allowance per man and horse may, for certain definite purposes and over very short periods of a day or two, be reduced to half a gallon and five gallons respectively, but as a rule both should be provided with as much water as they require, within reason.

The theory that men and horses can be trained to use a very small amount of water is not a sound one. It is better to start an operation with men and horses in the pink of condition than in a half-starved state. Therefore, in arranging for (*a*) the amounts should be considerably increased. But when this is analysed, the increase, except in very hot weather, when a horse may drink some 12 gallons, or even more, is due to the requirements of men only as regards washing, disinfection of clothing, and similar purposes.

3. The Division is divided for water purposes into four groups, viz :—

			Gallons per day.		
	Men.	Horses.	Men.	Horses.	Total.
Divl. H.Q. Group.	3,900	3,120	3,900	31,200	35,100
3 Brigade Groups (each)	5,000	1,530	5,000	15,300	20,300

The total requirements of a Division, on this scale, are therefore 95,400 or (say) 100,000 gallons per day.

The above figures are approximate for an Indian Division, but are near enough to facts for water purposes. A British Division requires somewhat less. Corps Troops vary in number, but may be taken at 10,000 men and 5,000 horses.

4. Where open water and flowing streams exist, and the red, white and blue flags can be used, no particular difficulty need be anticipated, but where every drop of water has to be dug for, or lifted from

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wells 100 ft. to 200 ft. deep, quite a different proposition presents itself.

5. The water distribution unit for animals is :—

1 L. & F. pump, complete with hose.
1 trough, canvas, 600 gallons * (nominal, but really some 350 gallons).

This unit, provided too great a duty is not put on the pump, can water, with good management, some 180 horses, or 54 camels, per hour. It should be noted that only 18 camels can use a trough at one and the same time, and each relay takes 20 minutes to water.

Each watering should be calculated as for 2 hours. Therefore each Brigade Group requires a minimum of 5 units, and the Divl. H.Q. Group requires 9 units, where it is essential to water entirely from troughs. As the watering is very often widely distributed, and as sometimes, where the source of supply is insufficient for a unit supply, a Division should carry no less than 36 units, or 12 per Field Company, of which some must be applied to mens' water.

For men the tank, canvas, 2,300* gallon (nominal, but really about 1,500 gallon) is required, for collection and chlorinating purposes, and some 10 of these are required per Division. The actual number depends greatly on how many water carts or other receptacles, in which chlorinating can be done equally well, are carried.

6. For storage, while at rest, large canvas bucksails, 30 ft. by 30 ft., specially proofed, and holding, when mounted on timber frames, or dug into ground, some 7,000 gallons, are often used. It is, however, highly desirable, in order to economise in these and in the 2,300-gallon tanks, and also in 600-gallon troughs, also if the duration of a halt is likely to justify this course, to construct masonry reservoirs, and wooden or even masonry troughs, in order to save the canvas reservoirs and troughs for mobile use.

7. Similarly, while at rest, it is extremely desirable to withdraw from use equipment pumps, and replace them by other pumps, in order that when a move occurs, all equipment shall be in first-class order.

8. Where water has to be dug for, it is not a practical proposition to expect a Division to be watered the night of arrival at its destination, where water occurs at more than 6 ft. underground. Where this state of affairs occurs in sandy soil, a great strain is thrown on the Royal Engineers, and it may be necessary to carry specially designed well linings, of corrugated iron on timber framings, making a well of 6 ft. by 6 ft.

Where the soil consists of coarse sand, perforated driving heads, known sometimes as spear points, sunk by means of the Norton Tube monkey, may be used in conjunction with the L. & F. pumps, but

* The method under which this gallonage was arrived at is not known.

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these are disappointing in fine sand or in clay or ordinary soil. They are specially useful for obtaining drinking water for men, as the risk of pollution is decreased by their use.

The Norton Tube sets are especially valuable in such cases in testing the depth of the water, but as means of supply, their yield being only some 200 gallons per hour, they are not of much use.

Shallow wells may be expected to yield from 300 to 500 g.p.h. and therefore some 20 wells per Division are necessary.

9. Where water is at depth below the reach of a L. & F. pump, there are two possible means of lifting, during operations, with great speed from open wells :—(*a*) L. & F. pumps in series, or stages ; (*b*) Water bags (with valve in base).

(*a*) is placed out of court at once, where the necessary stagings are not in existence ;

(*b*) is always possible, and is the best and quickest. With a good depth of water in the well, water at 100 ft. may be drawn up at the rate of upwards of 1,000 gallons per hour, with a 20 gallon bag, by man or horse power.

The last six inches of a well always give the greatest yield. The valve in the bottom of the bag can deal with this, but more slowly. This means of lifting water from depth is, on the whole, the most efficient when speed of erection is considered.

The yield of a deep well may be anything from 500 to 3,000 gallons per hour, or even more. A Division must, however, with such sources of supply, be considerably dispersed where yields are not great.

Where more time is available, a Chain Helice pump, driven by a 5 h.p. engine, yielding, at 150 ft. depth, 1,200 gallons per hour, is most useful, and takes only some 2 hours to erect. Where still more time is available, a deep well pump (preferably with a ball valve), driven by a 5 h.p. engine, yielding at 150 ft. depth, 1,000 gallons per hour, may be used, but this takes 9 hours to erect, and is therefore not of much use in rapid operations.

10. Where bore-holes are met with, it is often the case that the pump is either in working order or can be quickly repaired, but the engine is destroyed. The Lister type engine, of which each Division should carry two, can be used in such cases. An Isler pump is useful for bore-holes of 5 in. or upwards, but for smaller bores an Isler pump fitted with ball valves might be found suitable. Clack valves are unsuitable.

11. Where native-owned engines and pumps are found, it is often the case that the owners will have removed the magneto, and other essential parts. A little peaceful persuasion, with the promise of water for the owners' use will, as a rule, produce the missing parts, when all will be well.

12. Engines and pumps erected by the enemy cannot be relied

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upon. They are found, as a rule, in a wrecked condition, except where an advance has been so rapid as to upset all arrangements for destruction. It is unsafe to rely upon them for supply.

13. In preparing for a concentration, the supply from a well or bore-hole should be arranged at per Brigade Group or Divl. H.Q. Group, provided always the well or bore is of sufficient yield, and should be piped to the site of distribution. Each Brigade Group should be provided with 6 water points for troughs, and 1 water point for men. The former may consist of 3 standpipes with T head, not less than 30 ft. apart, to deliver into equipment or other troughs, and the latter should be a stand pipe to deliver into water carts, or it may deliver into a canvas tank, from which the water is pumped by hand into water carts, fanatis or other receptacles. (Fanatis are boxes of galvanised iron or copper, of 10 to 15 gallons capacity, for camel pack transport). The distribution for the Divl. H.Q. Group is larger in proportion.

Water prepared for concentrations in offensives must be so sited as to comply with tactical requirements.

As a rule, a Division in the attack is distributed in depth. The extent of front and depth depends entirely on the conditions of the campaign. An average distribution is by Brigade Groups, the leading water point being about one mile in rear of the front line, and succeeding Brigade Groups and Divl. H.Q. Group water points being at intervals, towards the rear, of as much as one or two miles. Where very large masses of troops are engaged these intervals must, doubtless, be reduced very considerably.

In the event of an offensive being directed towards a country devoid of water, except such as can be easily destroyed by the enemy, it may be necessary to allow for two or even three Brigade Groups per Division at the most advanced water point, in order that, if new water is not taken beyond the front line, it may be possible to send back to the most advanced prepared water point. These water points may be wells or bores, either existing and developed, or specially sunk, or pipe lines may be specially laid.

When laying pipes for tactical purposes (*b*) or domestic purposes as in (*a*) the general rule is to establish the pumping installation at a suitable source of supply as far back as possible within reason. Such distance will, of course, depend on the pumps or head available, as well as on the supply of pipes and specials.

Anyway, by adopting this rule, the headworks or pumps are placed in the safest situation, and as free as possible from shell fire or capture. When laying a pipe line it is as well to look forward to the possibility of extending it in the event of an advance, and to leave T's for use in the event of a retirement. Where wells or bores are used, they should be specially chosen for the suitability as regards invisibility, both of the site itself and the approaches.

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These remarks apply similarly to the domestic supply for a Division in the line.

14. Pipe lines may be laid from a source of supply behind the front line, to provide a supply to troops who have gained their objective. Where accurate contoured maps exist the matter does not present any great difficulties, but where heads have to be guessed at it may be necessary to erect relay sets at intermediate points.

The actual laying and screwing up of the pipes does not present any great difficulties. The success of the enterprise depends on the speed at which pipes can be transported to site and the extent to which the enterprise has been organised beforehand.

An example of the organisation of a pipe line construction is appended (see accompanying *Plan*). The source of supply was a large river, and a triple ram pump and 12 h.p. Robson engine were used. The delivery was 4,000 g.p.h. against a head of 200 ft. The line was laid and bucksails of 70,000 gallons capacity erected in 8½ hours. The work was carried out within full view of the enemy, but no interference was attempted. Labour used was almost entirely Native Egyptian.

15. It has been found necessary, where troops are expected to move through an absolutely waterless country, to provide Water Convoys. A Division, at the rate of ½ gallon per man and 5 gallons per horse, would require 4,400 fanatis of 12 gallons each, carried on 2,200 camels. The filling of these at speed must be arranged for, and can only be done with the use of reliable pumps and perfect organization. In addition to the filling of fanatis, the camels which carry them have to be watered.

16. In some countries, especially those possessed of an ancient civilization, most of the old native wells will be found to have very small yields. Where time admits, these should be cleaned out. As an example, no less than 24 ft. of sludge has been removed from a well 150 ft. deep, with the result that the yield was increased from 300 to 3,000 gallons per hour. To effect this clearing out, pumps with ball valves, and tripods with buckets, are essential. A boring outfit is most useful for this purpose.

17. Reports on water, when found, should be sent to H.Q. of formation without delay. The yield of a well cannot be accurately gauged without observing its behaviour over a period. It would suffice in the first instance if the number of troops watered at the well be stated and the opinion of the reporting officer. If the opportunity occurs, this report can be amplified later.

18. Where a country of springs is occupied, and information is indifferent as to the minimum yields, they should be gauged from the commencement of occupation, in order that an estimate of their minimum yields may be made. The yield of a spring sometimes reduces violently down to a minimum about half way through the

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dry season, at which level it remains constant. The behaviour of springs varies, of course, in different formations and different countries, so that no known rule applies.

19. The essential conditions of a water distribution area are :—

(*a*). Fairly level site.

(*b*). Sufficient room for barracking a certain number of animals in preparation for watering.

(*c*). Easy ingress and egress.

(*d*). Lines of troughs not less than 30 ft. apart in the clear.

(*e*). Animals should enter troughs at one end, and leave at the other.

(*f*). The supply to any trough must be sufficient for maximum number of animals watering at that trough.

If, for instance, a trough is 100 ft. long, and will water, therefore, 68 horses, using both sides, at one time, the supply to this trough should be not less than 68×4 gallons $= 272$ gallons in ten minutes, or at a rate of $272 \times 6 = 1{,}632$ gallons per hour.

(*g*). In some soils the standings must be hardened.

(*h*). Overflow water must be drained off.

20. The general conditions of water "tactics" or "strategy" (for want of a better word) seem to be as follows :—

(i). In a native country, where water exists at depth, and deep wells exist :—

(*a*). With fast moving troops—which implies fast retirement of the enemy, and that they have not destroyed the wells—water bags must be used ;

(*b*). Where the enemy retires more slowly, water bags may still be used, but to save the endless wear and tear on ropes and bags, power-driven Chain Helice pumps may be used.

(ii). Where water exists at depth, in a native country partly exploited by Europeans, it will be found that open wells, both native and European, and bore-holes exist.

(The European open wells and the bore-holes will be found fitted out with power pumps, some ready for use, and some in a worn-out condition) :—

(*a*). With fast moving troops, the open wells can be worked with water bags, the power pumps must be put in order quickly, and where necessary engines must be provided to work them. The engine will be more often found not fit for use than the pump. Hence 5 h.p. engines at the rate of two per Division should be carried.

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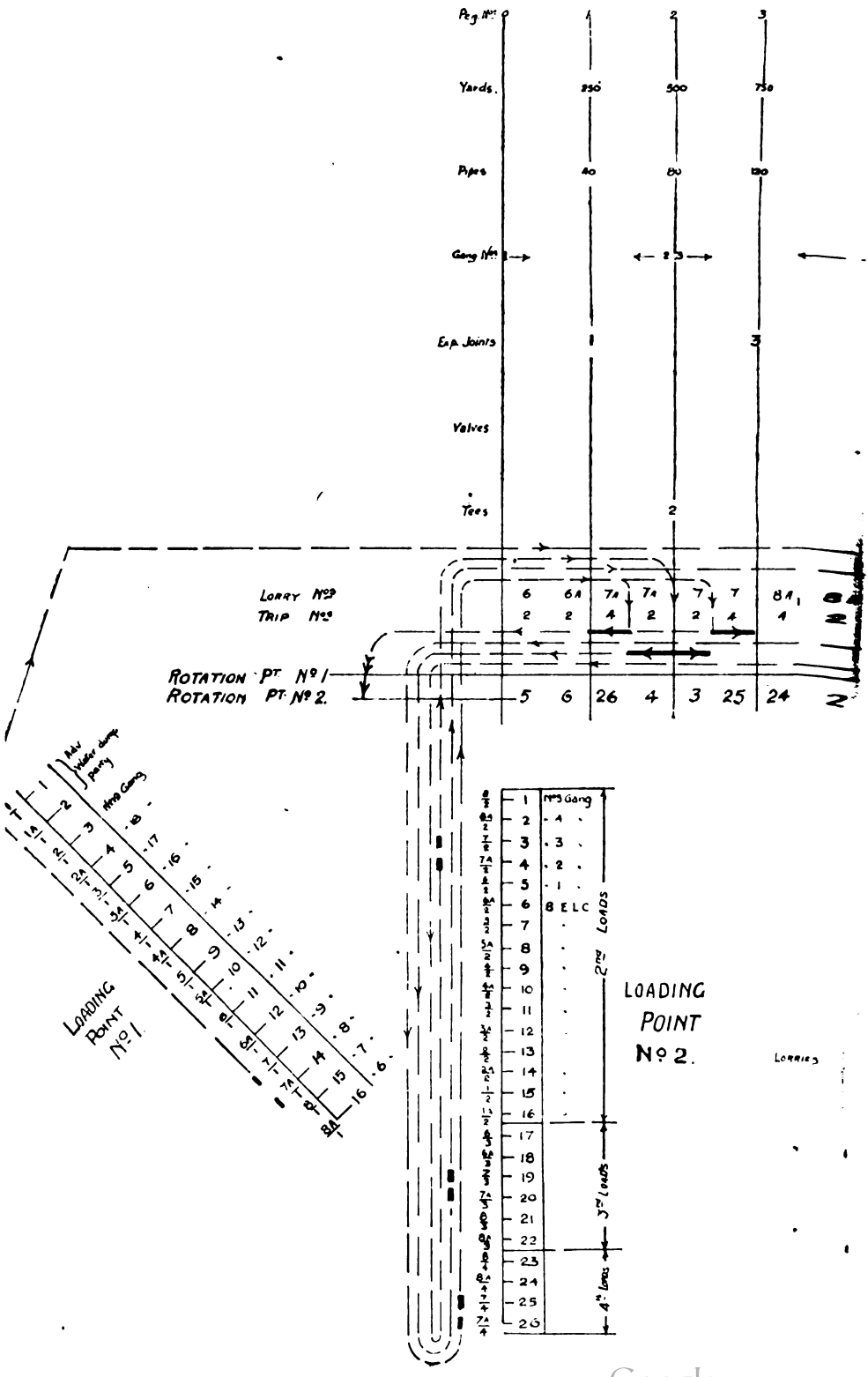

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(*b*). Where the advance is slower, a considerable amount of labour may be saved by carrying one Chain Helice and one Isler, or similar pump, per Division.

It may be necessary to carry some spare parts of engines and pumps most likely to be met with.

21. Where water is met with at 200 ft. or less with moderate certainty and conditions are generally suitable for quick boring, a properly organized and equipped Boring Company or Section is essential, where troops do not move too fast, and usual long halts are made, and for L. of C. purposes.

Where a Boring Section only is provided, it should be attached to the most suitable A.T. Coy. R.E. at the head of the L. of C. The Boring Company or Section should have access to the machinery shops, and should have a special agent stationed in these shops.

22. On a new line formations must be followed up for consolidation purposes by A.T. Coys. R.E. equipped with pumps of from 1,000 to 3,000 g.p.h. capacity.

23. When an Army has to use power pumps, and other machinery, a well organized repair shop is an essential. This shop may be located at an advanced base on L. of C. All pumps which are issued to the troops must be thoroughly overhauled by these shops before issue, and all engines must be given trial runs on testing blocks.

It is often the case that a tactical operation depends on the success of a water pumping operation. Hence any deficiency in machinery may easily upset the calculations in connection with the military operation.

As an Army advances, enemy shops which are worth while taking over should be brought into use. For such purposes, efficient workshop officers and staffs should follow the Army at the head of L. of C. whether attached, or posted, to A.T. Coys. R.E. or not.

24. The Hayward Tyler land set can be utilized for pipe lines, or may be used for filling six troughs or tanks at one and the same time. For the latter purpose an arrangement of canvas hose, fitted with W.I. Tee pieces, and provided with six water points, can be easily constructed and should be part of the outfit of the set. The Hayward Tyler set may be connected to six spear points connected together where suitable soil exists.

25. Where water is scarce, more appliances for lifting are required.

Where new countries are exploited by Europeans, and especially where German influence is felt, much machinery will be found. This was found to be the case in German S.W. Africa and Palestine. It is essential in such countries that units shall have on their Establishments many more engine drivers, especially in oil and petrol, than are authorized. A Division may have to work upwards of ten sets,

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entailing 3 engine drivers each. A Field Company should therefore contain from ten to fifteen of such engine drivers.

26. The oriental methods of raising water are often extremely efficient, and are useful when an Army is at rest. The Shadouf (Arabic), Dhingly (Hindustani) consists of a bucket hung by a rope to a swinging pole weighted at the end opposite to that to which the bucket is attached. This is capable of an average of upwards of 1,500 g.p.h. from a depth of some 6 ft.—the capacity entirely depends on the skill of the operators, and natives are far more adept than Europeans can ever become.

Sakkieh (Arabic), Arrat (Hindustani) is capable of some 3,000 g.p.h. at 40 ft. depth. It may be operated by men, oxen, camels, horses, mules, etc. This is the "Persian Wheel."

Chursa, used in India and Mesopotamia, capable of upwards of 1,500 g.p.h. at 40 ft.

27. Air lift pumps cannot be relied upon during operations, as wells with sufficient depth of water are very unusual. If, however, such a well is met with while the Army is at rest, an air lift pump could be brought up for the special purpose, and would doubtless be found most useful.

28. Among other suitable types of pumps and engines for service purposes are :—

Engines.	Pumps.
5 h.p. Lister.	Isler, deep well. 1,000 g.p.h. at 150 ft.
do.	Dando, deep well. 1,000 g.p.h. at 200 ft.
8 h.p. Lister. / 7 h.p. Blackstone.	Dando, deep well. 3,000 g.p.h. at 200 ft.

For cleaning out wells the Dando with its ball valve pump is most suitable.

5 h.p. Lister.	Chain Helice. 1,200 g.p.h. at 120 ft. (requires 18 in. depth of water.)
Hayward Tyler Land Set.	(4 h.p. Blackstone.) 3,600 g.p.h. against 100 ft. head.

Notes.—

Petrol or oil driven engines are, as a rule, essential on service. Native producer gas, steam, etc., and even Diesel engines are often found, and units must be capable of using them.

A peculiarity about the supply of water to troops in the field, is that the more they are supplied with, the greater are their demands.

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THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914—1919.

(*Continued.*)

BRIDGING.

CHAPTER II.

BRIDGING OPERATIONS PRIOR TO AUGUST, 1918.

Introduction.—Prior to 1917.—During 1917.—January to March, 1918.—April to July, 1918.

1. INTRODUCTION.

Actual Bridging operations during the War may be divided into five distinct periods:—

(1st). *Prior to* 1917, which was a period of strenuous preparation and training, but during which Bridging operations were of minor importance;
(2nd). *During* 1917. Operations following the withdrawal of the German Army to the Hindenburg Line;
(3rd). *January to March*, 1918. Preparations made in anticipation of a general German offensive;
(4th). *April to July*, 1918. Bridges necessitated by the withdrawal of the British Line; and—
(5th). *August to November*, 1918. Bridges erected during the final advance (described in detail in succeeding Chapter.)

These periods will now be described in detail.
Map B. shows the principal waterways referred to.

2. PRIOR TO 1917.

In the first months of the War a few timber Bridges of ordinary type were built.

During the Battle of the Aisne a heavy timber braced trestle bridge built by the 20th Fortress Company at Bourg was the principal means of communication to the British I Corps, and, when the front was taken over by a French Corps, the entire relief took place across this bridge during one night.

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Pending the arrival from England of the bridge work which had been ordered, a few steel spans (R.S.J. and Girder) were made up locally at Lillers and Armentiéres; some of these were utilised for the repair of low level bridges on the Lys between La Gorgue and Armentières, and on the River Lawe.

A wooden Girder Bridge (Central Span about 65 ft.) was also erected at Le Bizet, North of Armentiéres; this was replaced later by a steel Girder Bridge consisting of one 60ft. Class B. and four rolled steel joist spans on braced timber trestles.

Some of the earliest bridges were illustrated in the first Edition of "Memo. on Construction and Repair of Road Bridges."

The 20th, 25th, 31st, and 42nd Fortress Companies were all employed on this work during the end of 1914 and beginning of 1915. They also assisted in fitting out the Barge Depôts and Bridges,and in working out various details and designs.

The need for heavy bridging equipment, which Fortress Companies lacked, was one of the main causes of the conversion of these Units into Army Troops Companies, in whose equipment provision was made for special tackle, pile drivers, etc., and mechanical transport, as well as increased *personnel.*

3. DURING 1917. THE SOMME.

On the 17th March the Germans commenced to withdraw across the Somme in front of the British Fourth Army. On the following day the crossings came completely into our possession, and reconnaissances showed that the whole of the bridges had been destroyed. Work was at once commenced by the Field Companies of the 1st Division on temporary crossings, and Infantry were enabled to cross the same night.

Medium Bridges to carry first line transport were commenced the following morning, and a crossing was completed at 5 a.m. at Brie. There were six gaps in the original crossing over the Somme River and Canal, one across the Canal about 35 ft. broad, and five others 28 ft., 93 ft., 24 ft., 78 ft. and 61 ft. respectively.

On the 18th of March an interview took place between the Army and Corps Bridging Officers, and an Officer specially sent from the Bridging School, at which schemes for the erection of steel bridges were decided on. The required spans were at once despatched from the Base, and two train loads arrived at the Army Depôt on the 21st, and two more on the 22nd. From this Depôt all material had to be taken by horse transport a distance of about 10 miles, as the roads were unfit for M.T.

Before heavy bridging could be commenced a second set of medium bridges had to be erected, and the original ones which for the

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sake of rapidity had been built on the site of the old bridges, dismantled.

Some delay was also caused owing to a single truck being cut off *en route*, in which were packed the bolts for all the steel spans. The erection of the heavy bridges was carried out by the 23rd and 409th (Lowland) Field Companies, of the 1st Division, assisted by a detachment of an Army Troops Company, and working parties from two complete Infantry Battalions.

The entire crossing was ready for all heavy traffic at 4 p.m. on the 28th March.

The estimated date for the completion was the 30th, and a special message of congratulation to the Engineers of the Fourth Army was received from the Commander-in-Chief.

The details of Bridges were as follows :—

No. 1. Gap	...	...	30 ft. Span on crib piers.
No. 2. Gap	...	...	21 ft. 6 in. Span on crib piers.
No. 3. Gap	...	...	60 ft. Span on crib piers.
No. 4. Gap	...	...	16 ft. Span on crib piers.
No. 5. Gap	...	...	Filled in by means of a cofferdam.
No. 6. Gap	...	...	60 ft. Span on crib piers.

No particular difficulty seems to have been found in launching the girders, though none of the troops employed had had much previous training. The actual time taken in the erection of the five heavy bridges was a week.

When this same crossing had to be bridged in 1918, the work was completed within four days, which shows the advantage of previous experience, and of further opportunities for training.

This was the first heavy bridging operation of any importance carried out during the War, and it is interesting to notice the chief lessons which were reported by the C.E. of the Army.

They were as follows :—

(*a*). Spans used are generally longer than what had been calculated from the available information, owing to the destruction of abutments and approaches.

(*b*). Special arrangements are necessary for artificial lighting at night, so as to allow of continuous shifts. A.A. Searchlights were borrowed and were quite suitable. (Note—At this time night bombing was practically unknown).

(*c*). It is most essential to have a skilled Officer in general charge whose authority, irrespective of rank, must be paramount, and who must have a whole time Assistant.

(*d*). No trouble was found in assembling any of the spans. The workmanship of the steel was excellent.

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(*e*). An ample number of plans is required with each bridge, and they should be mounted on cloth to resist the weather.
(*f*). Transport of material needs most careful organising, and should be arranged for by the Army Chief Engineer.

The Engineer-in-Chief circulated these notes, and drew special attention to the necessity for the most careful preliminary reconnaissances and organisation of *personnel*, material, and transport, so that no time shall be wasted when work becomes possible.

Subsequently a number of other bridges were erected over the Somme and its tributaries, including four 60 ft. Spans, one 30 ft., and one 13 ft. in Peronne.

Arras. A few bridges were built by the Third Army during the Arras battle in April. The most important of these carried the main Cambrai road across the railway just north of Arras Station. This crossing had been completely destroyed by the explosion of an ammunition dump on Easter Sunday.

The 557th (Glamorgan) Army Troops Company started work a few days later, and spent a week clearing the débris under constant shelling, which continued during most of the work of erection.

At one time work was stopped by order of G.H.Q. for 2 days, and was resumed again. The entire crossing was finished in a fortnight more. Two bridges were built side by side, each consisting of a 60 ft. apan, 21 ft. 6 in. span, and a 14 ft. span carried on steel tube piers, which rested on concrete foundations. About 30 casualties were suffered during this work, mostly by the carrying parties.

The same Company next repaired a damaged girder bridge over the railway at Achicourt—wooden trestles were first inserted underneath, and the steel girders subsequently repaired.

Another important road bridge over a railway cutting near Arras was repaired under heavy fire by the 289th Army Troops Company, holes in the arches being filled with reinforced concrete, which required the erection of false work to a height of between 30 and 40 feet. Orders for this work were issued on the 16th April, and the bridge was re-opened for all traffic on the 11th May, during which period 14 R.E. and 83 others engaged in the work were killed or wounded.

Ypres—Poperinghe. During the Summer of 1917 a certain number of bridges were erected in Flanders, in which no special points of interest are to be found.

Preparations for Crossing the River Lys in 1917. In July, 1917, preparations were made for a possible crossing of the River Lys by the Second Army. Exact sites for proposed crossings could not be determined, but it was decided to provide, and have ready at accessible dumps, sufficient bridging material, stores and launching equipment

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to allow of the erection of two steel bridges at any two points on the river, also to provide the necessary pontoons and special superstructure to enable 2 R.S J. Heavy Pontoon Bridges for A. Loads to be quickly constructed at the selected sites, pending the completion of the steel bridges. Material for the steel bridges was collected partly from the Base, and partly from the Army Barge Depôt, into an advanced Depôt at Steenwerck. All material for the Heavy Pontoon Bridges was also assembled here. A subsidiary dump of heavy bridging stores and material was also formed on the right bank of the Canal at Merville. Materials for each separate bridge were carefully laid out and marked, and all material and stores made up into lorry loads for transport.

The projected operations were ultimately abandoned.

When the German advance in April, 1918, took place, these Depôts were overrun, and practically all the material lost, but during the subsequent advance of the British Army later in the year, the steelwork of the bridges was recovered intact together with most of the bridging stores, and was all used during the Second Army Advance.

4. January to March, 1918.

A general attack by the German forces was expected during the early part of 1918, against the Southern British Armies.

With a view to possible eventualities, a considerable amount of additional bridging was carried out on the Somme front during February and March. Existing bridges were doubled on the main routes, others strengthened to carry Tanks, and new ones erected. This work was organised by the C.E. Fifth Army, and was all carried out under the general supervision of the G.H.Q. Bridging Officer by the 216th A.T. Company, and two Companies of American Engineers. The 216th Company was specially picked out for this work on account of the O.C. and senior Subaltern of the Company having both passed specially good courses at the Bridging School. The American Army had asked to be supplied with various type spans for instructional purposes, and willingly agreed to a suggestion that they should instead send Units to assist in practical work on the Somme.

The complete scheme which was drawn up embraced 62 bridges, and of these 51 had to be completed before the 21st March. Nearly all types were represented, including a Hopkins 90 ft. span, several 60 ft., 30ft., 21ft. 6 in., and 16 ft. type AA. bridges, 6 Pont Levis, and 1 Portal Lifting Bridge. Work proceeded smoothly and rapidly, and the opportunity that it offered for progressive training to the Units engaged was most valuable. The very high standard of efficiency attained by these Companies in a comparatively short time showed clearly the results that could be obtained by training

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and practice, and this was fully borne out by the work of the 216th A.T. Company in the intensive bridging operations during the Autumn of 1918.

At the end of March all these Units became involved in the retirement of the Fifth and Third Armies, and became part of the so-called Carey's Force. As soon as they had been relieved they commenced the next stage of bridging on the Somme under the Fourth Army, and later in the Aire district.

5. APRIL TO JULY, 1918.

The success of the great enemy attacks on the British fronts during March and April not only involved the loss of a number of bridges and bridging stores, but also created the necessity for a large number of additional bridges behind the re-constituted front.

This work was carried out by the Second Army in the St. Omer area, by the First Army near Bethune, by the Fourth Army on the Somme east and west of Amiens, by the Director of Works in the Abbeville district, and under the G.H.Q. Bridging Officer in the neighbourhood of Montreuil. *Photographs* XVIII., XIX. and XX. show a 2-span 85 ft. bridge in course of construction at Beutin. The two spans were bolted together and launched by the cantilever method.

The Second Army work included a large number of Rolled Steel Joist spans over the mass of small streams in the low-lying Country north-west of St. Omer, as well as a considerable amount of pile work.

The troops engaged included the 216th A.T. Company, Canadian Railway Troops, and I.W.T. Units, the latter of whom did most of the pile driving, and also erected a 120 ft. Hopkins Bridge at Arques. This is shown in *Photograph* XXI.

The most important work done during this period was probably that of the Fourth Army east of Amiens, which was carried out under considerable difficulties immediately the line stabilised.

Troops engaged were the 216th and 574th Army Troops Companies, the 353rd E and M Company, and two Companies of American Engineers.

Much use was made during this period of the Inglis rectangular type bridge, which could be erected very rapidly, and dismantled and moved to a fresh site as soon as a permanent bridge was completed.

At Blangy the canalised Somme was first bridged by an 84 ft. length of Inglis, which was replaced by a continuous R.S.J bridge made up of 21 ft. 6 in. and 16 ft. stock spans on four 2 pile bents. A

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feature of the construction of this bridge was that the spans were assembled on pontoons, floated into position, and the piles driven from the bridge, the pile drivers being so arranged that piles could be driven simultaneously on each side of the bridge.

At the conclusion of these operations the Chief Engineer reported the most important lesson learnt to be that the success of heavy bridging operations on a large scale must depend very greatly on :—

1. The loading of the trains at the base.
2. The organisation at railhead and dumps.
3. The organisation of road transport.
4. The liaison between base, railhead, dumps and receiving unit.

In no case was there difficulty or delay in assembling and launching spans at the bridge sites. A good deal of difficulty was experienced with approach roads at the new sites, and in several cases long lengths of new plank road had to be made across the marshy ground in the Somme Valley. A typical example is shown in *Photograph* XXII.

Additional crossings were next made between Amiens and Abbeville. This work was delayed by frequent changes in the Units engaged, the 574th A.T. Company finally being left to complete the work alone.

A Hopkins 105 ft. span erected at Hangest-sur-Somme gave some trouble owing to the proximity of the main railway line, which was an obstacle to the launching arrangements. The back guys of the launching derricks had to cross the line at a sufficient height to allow trains to pass underneath. An overhanging spar on one of the trucks of the fifth train to pass struck the guys during launching operations, which fouled the train, causing a delay of 24 hours

At Long a series of spans was erected on pile bents. The piles provided were 27 ft. long, and it was found necessary to splice on the top of each a lengthening piece of 13—15 feet. in order to obtain sufficient bearing stability.

A mechanical pile-driver was used here for the first time in the Fourth Army. It consisted of an 8 horse-power Lister petrol engine driving a small friction winch, and an ordinary derrick. This was found an improvement on hand piling, but the apparatus was not altogether satisfactory.

Several lifting bridges were erected, and the light lifting gear of the Portal type gave a good deal of trouble.

Special attention was again given to the receipt of material at railheads, and the transportation to, and unloading at, sites, all

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the arrangements being carried out without a hitch, and without any single deficiency in stores occurring.

Photograph XXIII. shows a standard 21 ft. 6 in. span, and *Photograph* XXIV. an 84 ft. length of Inglis Rectangular with a replacement bridge alongside consisting of two 21 ft. 6 in. and two 16 ft. spans.

(*To be continued.*)

[Previous articles under the heading of "The Work of the Royal Engineers during the European War, 1914–19" appeared in the *R.E. Journals* of September, 1919 (Introduction p. 105; Anti-Aircraft Searchlights, France, p. 106; Postal Section—Army Postal Services, p. 114) and October (Bridging, Chapter I, p. 162). Copies of these Journals may be obtained through the usual channels.]

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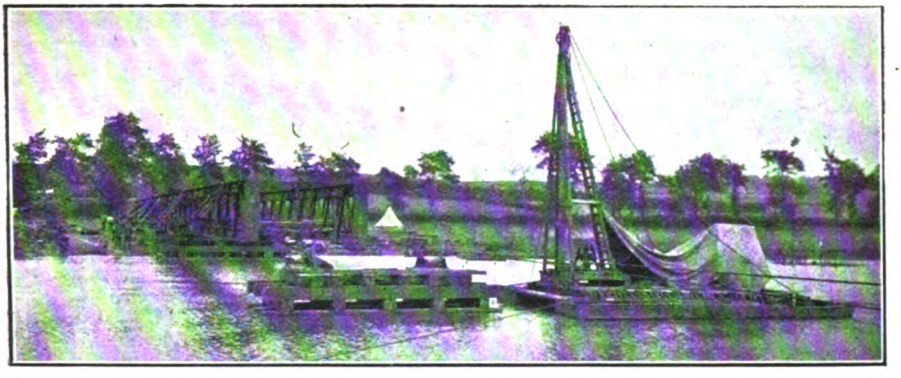

Photograph XVIII.

Photograph XIX.

Photograph XX.—Erection of a Two-Span 85ft. Bridge at Beutin.

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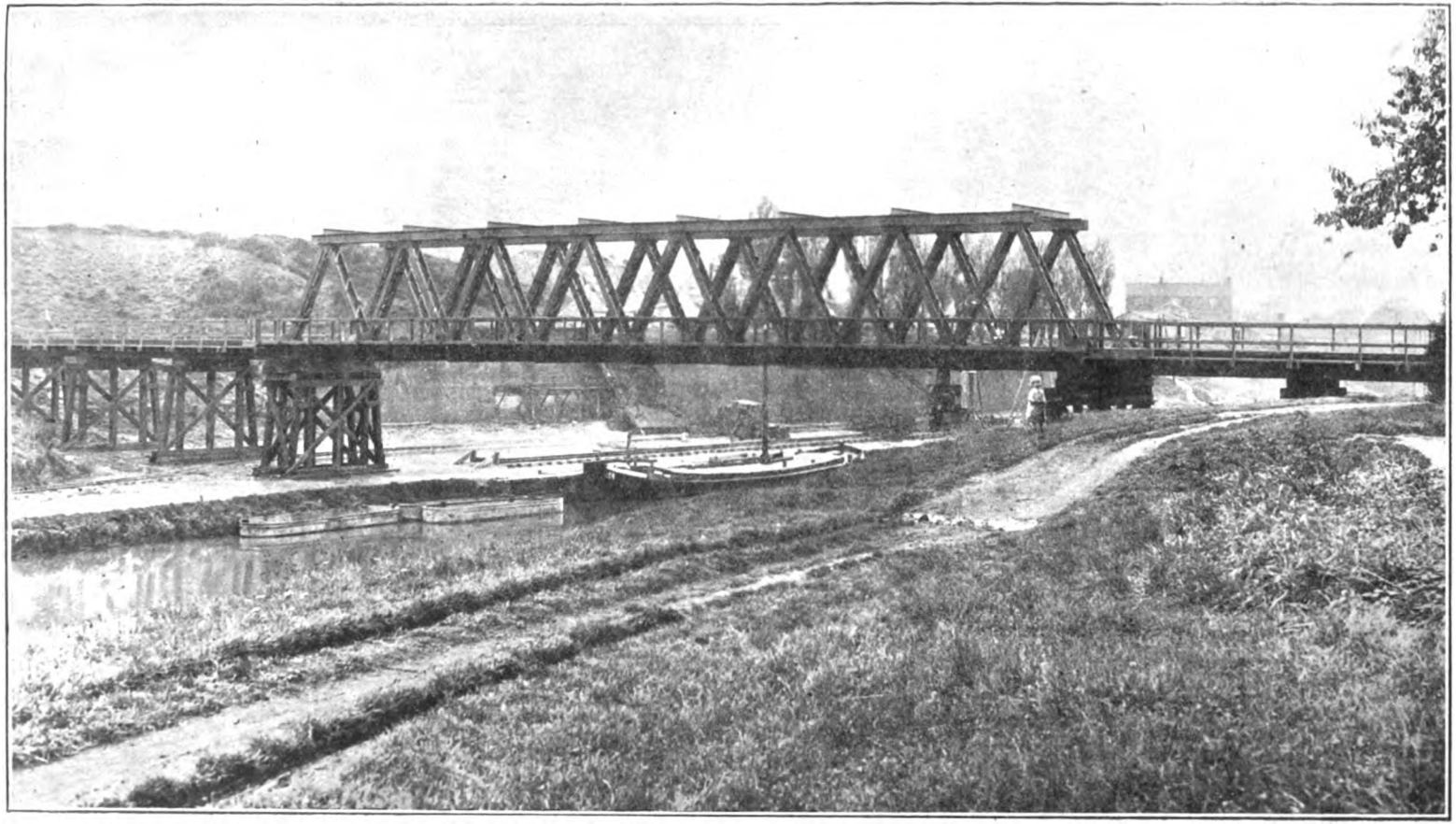

Photograph XXI.—120ft. Hopkins' Bridge at Arques.

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Photograph XXII.—Timber Approach to Bridge at Tronville Chateau, April 1918. 4th Army.

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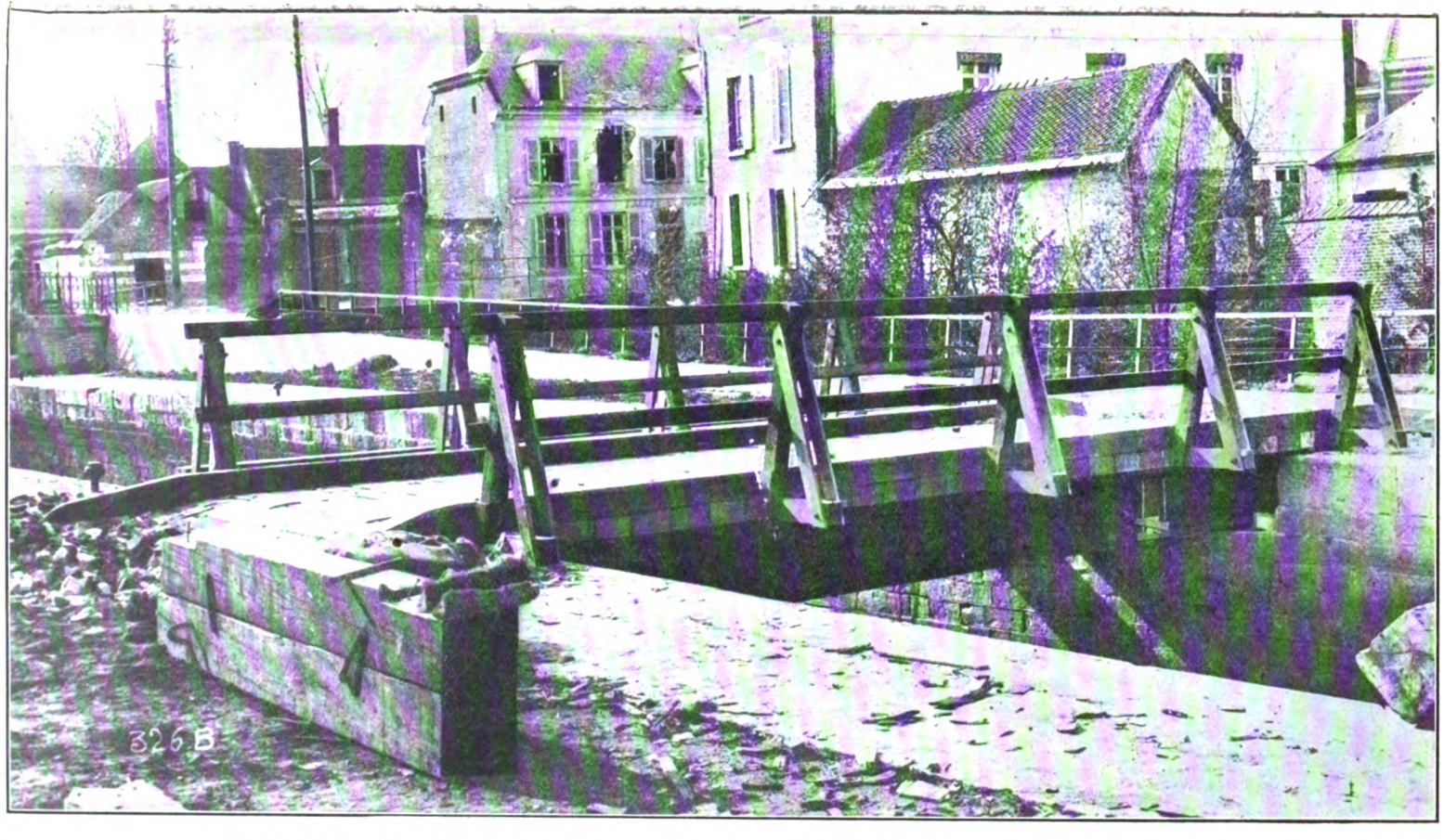

Photograph XXIII - N2. 21-ft. 6-in. Span, Mark II., at Fouilloy (Corbie), April, 1918. 4th Army.

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Photograph XXIV. K. 84-ft. 0-in. length of Inglis Rectangular Type at La Motte, April, 1918; also to the right is shown K1 Replace-

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THE DESIGN OF ROOFS.

By LIEUT.-COL. H. L. LEWIS, D.S.O., R.E.

EVEN before the war it occurred to many officers that recognized methods of designing roofs gave results that erred very much on the side of safety, not to say extravagance.

During the war, and especially in its later stages, the shortage of material enforced a reduction in the size of members, and it was found that roof structures cut down to a fraction of the strength that would have been considered normal in peace time, were able to fulfil their purpose, and, in exposed situations, to survive repeated storms.

It became evident that the theory of roof construction required investigation and drastic revision to bring it into line with the experience recently gained.

2. It is for the purpose of propounding some ideas and of inviting a discussion that this short article has been written.

Essentially, a roof consists of a "covering" and of a structure whose function it is to maintain that covering in place under all conditions except the most abnormal.

It is now suggested that past practice resulted in some, if not all, of these members being made very considerably stronger than safety demanded.

That the pure theory of roof design was at fault, may be ruled out at once, for this theory is the same as is applied to other engineering structures, and is based on very numerous experiments.

We may attribute any errors that may have arisen to one of two causes :—

(1). A faulty arrangement of the members.
(2). An excessive estimate of the load that might be imposed.

As regards the first of these, it must be admitted that a very large number of roof structures are imperfect. The spacing of the trusses, the number of the points at which the principal rafters are supported by struts, the spacing of rafters, are considerations which all have their effect on the economy of design, and in the aggregate may easily make a difference in cost of ten or fifteen per cent.

Such questions rarely receive sufficient attention. Joints are often designed so as to bring about large and avoidable secondary

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stresses, and to meet these members must be made heavier than would otherwise be necessary. These secondary stresses are never calculated, or directly provided for, but as a sufficient factor of safety must be obtained, theory is made to square with practice by allowing for a roof load greatly in excess of whatever actually occurs.

3. Let us consider how the roof load is estimated and whether the customary allowances are in fact justified.

The permanent loads allowed for are actual existing loads, and it is only a question of estimating or measuring them correctly. This can always be done with sufficient accuracy, if not at the first, then at the second or third attempts.

There remain to be considered the allowances which should be made for the various temporary loads which may be imposed, whether due to the weight of workmen, weight of snow, or to wind pressure.

4. Firstly as regards weight of workmen.

A very usual allowance in this case is 25 lbs. a foot super., which is considered applied to battens, to common rafters, to purlins, and to trusses. In order to appreciate what this means, let us apply this allowance to a roof with a clear span of 40 ft., with trusses 10 ft. apart. The length of principal rafters will be about 24 ft., and we may assume that the purlins are spaced 6 ft. apart. Assume that the common rafters are 2 ft. apart, centre to centre, and that battens are spaced at 1 ft.

A load of 25 lbs. dead load per foot super means on each common rafter, a dead load of 300 lbs.; on each purlin, a dead load of 1,500 lbs.; on each truss, a dead load of 12,000 lbs. So that, so far as workmen are concerned, the assumed load is equivalent to about :—

$1\frac{3}{4}$ workmen on each common rafter,
9 workmen on each purlin,
70 workmen on each truss,

taking the weight of one workman at about 170 lbs.

Stated in this way, it is evident that, whereas 25 lbs. a foot super. is not an unreasonable allowance for workmen in considering the load that may come on a common rafter, it is a wholly absurd allowance as applied to a purlin or to a truss.

A common rafter may have to bear the bulk of the weight of a single workman, being live load and not too well distributed.

A purlin is most unlikely to have to bear more than four workmen at one time, at the very outside, or a total load of 680 lbs.

If any of the overlaying structure is in place, this load will be fairly well distributed, and as the men will have to move cautiously it may be considered a very nearly dead load. If, on the other hand, the superstructure has not been placed, the load is less well distributed

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and is more suddenly applied, but on the other hand, the permanent load is absent.

We may assume here that, for four workmen, a total load allowance of 680 lbs. or at the rate of 11½ lbs. a foot super is well up to the mark.

Were the purlins spaced closer together, there would be proportionately fewer workmen on each, and the same allowance, say 12 lbs. a foot super would be ample.

The truss will never have to support 70 workmen at one time. We may put the maximum number conceivable for a roof of this span at 10 on each side, which works out to an allowance of 7¼ lbs. a foot super. of roof slope. Such loads can always be considered dead and distributed.

It should be noted with regard to rafters, purlins, and trusses that a factor of safety will be applied to both permanent and temporary loads and that the former being invariable, the actual margin available to meet unusual variations of the latter is greater than is apparent at first sight.

It would appear therefore, that for the roof which is being considered, and for all similar roofs, the following would be a fair and sufficient allowance for workmen, provided the ordinary rules for good construction are followed:—

On battens and common rafters	25 lbs. per foot super.
On purlins	12 ,, ,, ,,
On trusses	7½ ,, ,, ,,

5. *Allowance for Snow.*—In England, it is rare for any considerable quantity of snow to lodge on a sloping roof. If the slope of the roof exceeds 45°, no allowance need be made. On flatter roofs, and in the absence of strong wind, a considerable thickness of snow may collect and may remain for several days.

The average weight of fresh snow is about 8 lbs. a cubic foot, and on a roof of very flat pitch this might accumulate to a depth of two or even three feet. On the average slate or tiled roof a depth of one foot is about the maximum, and an allowance of 8 lbs. a foot super is sufficient. This allowance applies equally to battens, rafters, purlins and trusses.

6. *Allowance for Wind Pressure.*—The pressure which can be exerted by wind has given rise to much discussion in the past, and fantastic allowances, some even as high as 56 lbs. to the square foot, have been applied to structures.

Over a period of seven years, the highest wind pressures recorded at the Firth of Forth bridge, on two surfaces, one of 1½ square feet, the other of 300 square feet, were 41 lbs. a square foot and 27 lbs. a square foot respectively. The surfaces experimented on were

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placed high above the ground, in most exposed situations, and the locality is liable to very severe gales.

More recent experiments give results which agree closely with one another and which are expressed by the formula :—

$$P = \cdot0032 \times V^2, \text{ when}$$

P is the pressure in lbs. per square foot,
V is the velocity in miles per hour.

What in Beaumont's scale is known as a " fresh gale " corresponds to a wind velocity of 48 miles per hour, whilst a " full gale " has a velocity of 67 miles per hour.

These would exert a pressure on a surface normal to the direction to the wind of 7·36 lbs. a square foot and 14·4 lbs. a square foot respectively, whilst a hurricane of 100 miles an hour would exert a pressure of 32 lbs. a square foot.

Now in England, buildings are rarely placed in very exposed sites ; the force of the wind is much broken by the unevenness of the ground, by trees, and by the proximity of other houses.

In very exposed sites, special allowances should be made, but there is no reason why these allowances should be also applied to buildings in ordinary situations.

For a moderately exposed site it is suggested that a wind velocity of 48 miles an hour, with a pressure of 7½ lbs. a square foot, and for an exposed site a velocity of 60 miles an hour, with a corresponding pressure of 11½ lbs. a square foot will be enough.

For a tall chimney, or other high and isolated structures, a velocity of 80 miles an hour, and a wind pressure of 20½ lbs. a square foot might be provided for.

All of the foregoing pressures refer to a surface normal to the wind.

For a roof sloping at 1 in 2, the pressure would be ·7 of the above, and for a roof of 1 in 1, ·95 of the above. For the ordinary pitch of 4 in 7, we may assume that the actual pressure, in an exposed site will not exceed ·87 × 11½ lbs. or 10 lbs. a square foot.

7. Summing the foregoing results, and remembering that with a strong wind, there can be neither snow nor workmen on the roof ; and that when there is snow, at most one or two workmen will get on the roof to clear it, and that they will not proceed beyond the eaves until they have cleared as far as they can reach, we arrive in the last column at the maximum allowances that appear necessary.

Member.	Workmen.	Weight of Snow.	Wind Pressure.	Maximum Temporary load.
Battens and Common Rafters.	25	8	10	25
Purlins	12	8	10	12
Trusses	7½	8	10	10

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In the case of an ordinary site, not exposed to the full force of the wind, the allowance for a truss might be further reduced to 8 lbs.

8. Our load for purposes of calculation, in the case of a roof consisting of slates resting on battens, will then work out as under :—

For Battens and Rafters.

Weight of slates	6 lbs. per ft. super.
,, ,, battens	1 ,, ,, ,,
,, ,, C rafters	1 ,, ,, ,,
Occasional load	25 ,, ,, ,,
Total	33 ,, ,, ,,

For Purlins.

Weight of slates, battens, and common rafters	8 lbs. per ft. super.
Weight of purlin	1 ,, ,, ,,
Occasional load	12 ,, ,, ,,
Total	21 ,, ,, ,,

For Trusses.

Weight of slates, battens, common rafters, and purlins	9 lbs. per ft. super.
Weight of truss	6 ,, ,, ,,
Occasional load	10 ,, ,, ,,
Total	25 ,, ,, ,,

9. As the strength of a roof is the strength of its weakest part, it is believed that a roof design based on the foregoing allowances will be no less safe than if the under portion of the structure were calculated with a higher load allowance, or what comes to the same thing, with a higher factor of safety. That such structures can be reduced much below their ordinary strength without undue risk has been proved during the war. The present cost and shortage of materials make it necessary that every possible economy should be effected, and it appears well worth considering whether some considerable economy may not be effected by adopting the system that has been explained at some length in the foregoing pages.

One warning is however necessary.

If roof trusses are to be calculated strictly in accordance with the loading that will be imposed, and not for a loading greatly in excess, it is imperative that the design should be a sound one, and that it should not involve stresses for which no allowance has been made.

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Reference is especially made to a very common fault in design, viz., failure to ensure that the stresses brought to a joint by two or more members, together with any load whether upward or downward, that is applied at that joint, should actually meet at a point. Only too frequently, the stresses are brought together so eccentrically, that surprisingly large bending moments are superimposed on direct thrusts and tensions, with the result that stresses are often two or three times as great as they are intended to be, or need be. With very little care, such secondary stresses can be almost completely eliminated and the truss can therefore sustain a much greater *properly* applied load than if this point were neglected.

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THE 11th (FIELD) COMPANY, R.E., AT THE BRICKSTACKS CUINCHY, ON 6th FEBRUARY, 1915.

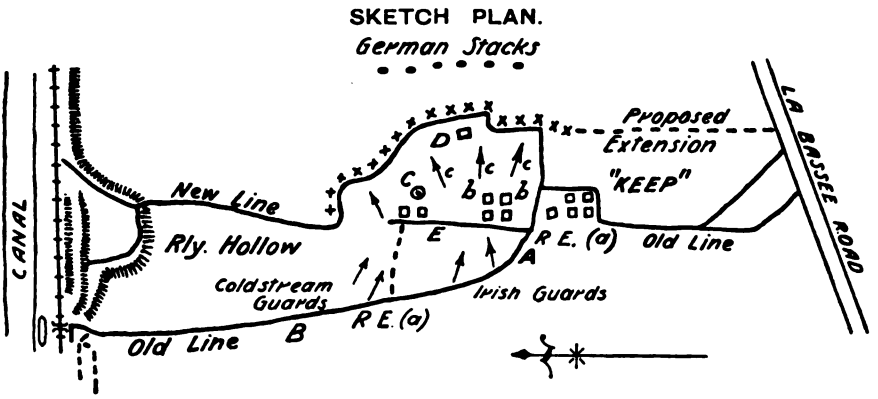
EXTRACT FROM REPORT OF O.C. 11TH (FIELD) COMPANY, R.E.

IN compliance with the Brigade Order that "the O.C., 11th Company, will detail two parties to follow the assaulting columns, strength being left to his discretion," the company paraded at 11.15 a.m. on the 6th February, 1915, in the neighbourhood of the Keep at Cuinchy Brickstacks, 50 rounds extra ammunition having been issued to each man. Total strength—4 officers and 90 Other Ranks. Each man carried one pick and shovel and 20 empty sandbags.

The interval before the assault was occupied in accumulating a stock of sandbags in the Keep.

One section (1 officer and 25 O.R.) was detailed to report to the Officer Commanding Coldstream Guards in the Railway Hollow, and the remainder, under the O.C., assembled at Point A in the keep, at a sandbag barricade blocking the German trench E.

After the artillery bombardment, as soon as the Irish Guards had reached the point E, the barricade just referred to was torn down, and when the assaulting party vacated the trench E and moved eastwards, the O.C. Company entered the trench, followed by two sections and gained the two stacks *b b* ; one officer with the 4th Section was left in reserve at A.



Immediately the assaulting troops came to a halt, the Engineers were distributed along their line and half-an-hour's hard digging

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followed, fire being kept up along the line. An advanced Keep was also established in the stack C and the communications throughout were improved.

The section in reserve was meanwhile brought up, making several journeys, carrying and distributing sandbags to the infantry. By this time it was possible to move about freely, and the O.C. was able to adjust the line, taking advantage of all natural features, connecting up scattered parties, joining together the two battalions and finally effecting a good junction with the Railway Hollow.

Close rifle fire had now ceased and it was possible to walk out to the front almost up to the German stacks (see *Plan*). The O.C. reconnoitred the German communications running into the British line, and got parties to work, blocking some half-dozen of them with sandbag barricades, and shaving down the sides of trenches to the front, so as to allow as long a straight field of fire down them as possible.

The fire trench was now sufficiently established, and the whole of the company was withdrawn (leaving their tools to the infantry) and sent to the R.E. depôt at Cuinchy for wire. Here a stock had been accumulated some days previously in anticipation of this attack. It was about 4 p.m. when wiring commenced, but it soon had to be discontinued, as a small group of the enemy opened fire from the stacks which were only about eighty yards off.

The wiring party got back to cover, only one sapper having been hit out at the entanglements.

At dusk the wiring was continued and the whole of the front between the lines of brickstacks was completed. This was the most important portion of the line, as a counter-attack could have been massed behind the German stacks unseen.

About 500 yards of front was wired, two rows of French roseaux Brun wire (in places, three rows), reinforced with strands of barbed wire, being laid and picketed down. The following night the remainder of the line was wired.

The new brigade line was excellently adapted to the ground and included the solitary stack D, thus denying the enemy a likely base for mining operations and sniping.

The report of Brigadier-General Lord Cavan, Commanding the 4th Brigade, stated that 340 yards of wire entanglement, 10 yards deep, were erected by the 11th Field Company, under Major Foulkes, in broad daylight, between 2.30 and 4.30 p.m., and the Divisional Commander, Major-General Sir H. S. Horne, warmly commended the devoted skill of all ranks of the Company in Division Orders.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
West Riding Div. H.Q.			
No. 1 Field Co.	1/1 455th Field Co., 29th Div., France.	2/1 458th Field Co., 49th Div., France.	3/1 461st Field Co., 62nd Div., France.
,, 2 ,, ...	1/2 456th Field Co., 49th Div., France.	2/2 459th Field Co., 6th Div., France.	See also note below.
,, 3 ,, ... (Not pre-war).	1/3 457th Field Co., 62nd Div., France. (*Not* pre-war.)	2/3 460th Field Co., 62nd Div., France.	See note below.
		Note.—The 4/1, 3/2 and 3/3 became Group, which was reorganized later.	464th Reserve Field Co., Northern See note against 3rd line of Northumbrian R.E.
Signal Co., West Riding Divl. Signal Co.	1/1 49th Div. Sig. Co., France.	2/1 62nd Divl. Signal Co., France.	3/1 W. Riding Signal Co. was merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
North Midland. H.Q.			
1st Field Co.	1/1 465th Field Co., 46th Div., France.	2/1 468th Field Co., 46th Div., France.	3/1 470th Field Co., 59th Div., France. See also note below.
2nd ,, ...	1/2 466th Field Co. 46th Div., France.	2/2 469th Field Co., 59th Div., France.	See note below.
3rd ,, ... (Not pre-war.)	1/3 467th Field Co., 59th Div., France. (Not pre-war.).	2/3 . See note against 3rd Line.	No 3/3 formed. See note below.
		Note.—The 4/1, 3/2 and 2/3 became the Group, which was reorganized later.	473rd Reserve Field Co., Northern See note against 3rd line of Northumbrian R.E.
Signal Co., North Midland Divl. Signal Co.	1/1 46th Divl. Signal Co., France	2/1 59th Div. Signal Co., France.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
South Midland. H.Q.			
No. 1 Field Co.	1/1 474th Field Co., 48th Div., Italy.	2/1 477th Field Co., 48th Div., Italy.	3/1 479th Field Co., 61st Div., Italy. See also note below.
„ 2 „	1/2 475th Field Co., 48th Div., Italy.	2/2 478th Field Co., 61st Div., France.	See note below.
„ 3 „ ... ... (Not pre-war.)	1/3 476th Field Co., 61st Div., France. (Not pre-war.)	2/3. See 3rd Line.	See note below.
		Note.—The 4/1, 3/2 and 2/3 Field Cos. became the 482nd Reserve Field Co., 9/Engrs./7611, d. 8. 1. 17, which, with the 508th Wessex Reserve Field Co., formed the Southern Group Reserve Field Cos., A.C.I. 2420 of 1916. The Southern Group Reserve Field Cos. became the 5th Reserve Battn., R.E. (which also absorbed the Reserve Depot of the Royal Naval Div., R.E.) on reorganization by 20/Engrs./5214 (A.G.7.) of 12. 1. 18. The 5th Reserve Battn. was subsequently reorganized (some *personnel* going to 2nd Reserve Battn., etc.) into a Tank Bridging, T.C., consisting of a Headquarters Tank Bridging, T.C., and three Tank Bdg. Battns. R.E., 20/Engrs./5325/5326/5327. The Headquarters Tank Bdg., T.C., and the three Tank Bdg. Battns., R.E., are being broken up and only an Experimental Tank Bdg. Co. is proposed for retention at present. See 20/Engrs./5345.	
Signal Co., South Midland Divl. Signal Co.	1/1 48th Div. Sig. Co. Italy ...	2/1 61st Div. Signal Co., France.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
Wessex Div. H.Q.			
No. 1 Field Co.	1/1 500th Field Co., 27th Div., Salonika.	2/1 503rd Field Co., 58th Div., France.	3/1 Became (with the 2/7th Hants converted Field Co.) the 508th Wessex Reserve Field Co. For subsequent reorganizations see Note against 3rd line of S. Midland R.E., T.F.
„ 2 „	1/2 501st Field Co., 27th Div., Salonika.	2/2 504th Field Co., 58th Div., France.	3/2
„ 3 „ ... ... (*Not* pre-war.)	1/3 502nd Field Co., 57th Div., France. Not pre-war.	2/3 505th Field Co., 57th Div., France.	3/3
Signal Co., Wessex Divl. Signal Co.	1/1 27th Div. Signal Co., Salonika.	2/1 58th Div. Signal Co.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.

Note.—It will be observed that units of the 43rd and 45th (Wessex) Divs. were transferred to the 27th Div. Regulars, the 58th (1st London) Div. and the 57th (West Lancashire) Div.

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Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Divisional Field Cos., R.E. (T.F.)			
E. Anglian Div.			
H.Q.			
No. 1 Field Co.	1/1 483rd Field Co., 2nd Div., France.	2/1 486th Field Co., 54th Div., Egypt.	3/1 488th being disbanded since 24. 10. 18. 20/Engrs./5334 (A.G.7 B.) 24. 10. 18.
,, 2 ,, ...	1/2 484th Field Co., 54th Div., Egypt.	2/2 487th Field Co. Being disbanded since 24. 10. 18. 20/Engrs./5334. Completed disbandment 22. 2. 19.	
,, 3 ,, ... (Not pre-war.)	1/3 485th Field Co. Being disbanded since 24. 10. 18. 20/Engrs./5334. Not pre-war.	Amalgamated with Reserve Field Co. See note against 3rd line.	
		The 4/1, 3/2 and 2/3 became the 489th Reserve Field Co. (9/Engrs./7611 (A.G.7.) d. 8. 1. 17), which, with the 499th (Home Counties) Reserve Field Co. formed the Eastern Command Group Reserve Field Cos. A.C.I. 2420 of 1916. This group was broken up; the *personnel* to the 5th Reserve Battn., R.E., Christchurch. 20/Engrs./5214 (A.G.7.), d. 12. 1. 18. For further reorganization of 5th Reserve Battn., R.E., see South Midland R.E., T.F.	
Signal Co. East Anglian Div. Signal Co.	1/1 54th Div. Signal Co., Egypt.	Disbanded was the 2/1 (69th Divl.) Signal Co. Disbandment in progress since 24. 10. 18. 20/Engrs./5334.	3/1 merged into S.S.T.C. See A.C.I. 1438 of 1916 and 615 of 1917.
Home Counties Div.			
H.Q.			
No. 1 Field Co.	1/1 490th Field Co., 8th Div., France.	2/1 493rd Field Co. } Being disbanded since 24. 10. 18 under W.O. letter 20/Engrs./5334 (A.G.7.b.).	The 3/1, 3/2 and 2/3 Home Counties and 2/1, 2/2 and 2/3 Kent (Converted) Field Cos. became the 499th (Home Counties) Reserve Field Co. (See 9/Engrs./7611 (A.G.7) of 8. 1. 17), which, with the 489th E. Anglian formed the E. Cd. Group Reserve Field Cos. A.C.I. 2420, 1916. The Eastern Group Reserve Field Cos. reorganized by 20/Engrs./5214 (A.G.7.b.) d. 12. 1. 18. See 3rd line of East Anglian R E., T.F.
,, 2 ,, ...	1/2 491st Field Co., 5th Div., France.	2/2 494th Field Co. }	

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
No. 3 Field Co. ... ... (Not pre-war.)	1/3 492nd Field Co., North Russian E.F. 0194/5451. (Not pre-war.)	Amalgamated with Reserve Field Co.	No 3/3 Field Co. formed. See above.
Signal Co. Home Counties Div. Signal Co.	1/1 28th Div. Signal Co.	2/1 Signal Co. was for some time the 67th Div. Signal Co., but on the break up of the 71st, 72nd and 73rd Home Service Divs., the 71st Div. Signal Co. was re-numbered 67th, and the 2/1 Home Counties Signal Co. was broken up. 20/Engrs./5229.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
1st London Div. H.Q.			
No. 1 Field Co.	1/1 509th Field Co., 6th Div., France.	2/1 512th Field Co., 56th Div., France.	The 3/1, 3/2 and 2/5 First London Field Cos. formed the 516 (1st London) Reserve Field Co. 9/Engrs./7611., which, with the 525th (2nd London) Reserve Field Co., formed the London Group Reserve Field Cos., T.F., Esher. A.C.I. 2420, 1916. The London Group was broken up and *personnel* distributed to the 1st and 2nd Reserve Battns., R.E., at Chatham and Chattenden. See 20/Engrs./5214. (A.G.7.) d. 12. 1. 18. For further reorganization of the 2nd Reserve Battn. see 20/Engrs./5323.
,, 2 ,, ...	1/2 510th Field Co., 29th Div., France.	2/2 513th Field Co., 56th Div., France.	
,, 5 ,, ... (Not pre-war.)	1/5 *Not* pre-war. 511th Field Co., 58th Div., France.	Amalgamated with Reserve Field Co. See 3rd line.	
Signal Co. 1st London Divl. Signal Co.	1/1 29th Div. Sig. Co., France.	2/1 56th Div. Signal Co., France.	3/1 Signal Co. merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
2nd London Div. H.Q.			
3rd Field Co.	1/3 517th Field Co., 47th Div., France.	2/3 520th Field Co., 47th Div., France.	3/3 522nd Field Co., 7th Indian Div., Egypt.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
4th Field Co.	1/4 518th Field Co., 47th Div., France.	2/4 521st Field Co., 60th Div., Egypt.	The 4/3, 3/4 and 2/6 2nd London Field Cos. formed the 525th (2nd London) Reserve Field Co., 9/Engrs./7611, which, with the 516th formed the London Group Reserve Field Cos. For details of further reorganization see 3rd line of 1st London R.E., T.F.
6th ,, ... (Not pre-war.)	1/6 519th Field Co., 60th Div., Egypt.	Amalgamated with Reserve Field Co. See 3rd line.	
Signal Co. 2nd London Divl. Signal Co.	1/2 47th Div. Signal Co., France.	2/2 60th Div. Signal Co., Egypt.	3/2 merged into S.S.T.C. See A.C.I.'s 1438 of 1916 and 615 of 1917.
Mixed Brigade Signal Sections. Not pre-war Units. When first formed during war they were the Signal Sections of the Provisional Field Cos.	Nos. 221, 222, 223, 224, 225, 226, 227 being disbanded by 20/Engrs./5334 (A.G.7.b.) of 24. 10. 18.		

PROVISIONAL FIELD COS.—Later known as Mixed Brigade Field Cos. :—

1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th	These Units were formed under authority of W.O. file No. 79/7269. (See A.G.I. letter d. 24. 4. 15 and "Instructions issued by W.O." Nos. 35 of June, 1915, and 31 of July, 1915.) The units consisted of 2 Field Sections and 1 Signal Section each.	Re-numbered	640th (Lowland) Field Co. by 9/Engrs./7611 (A.G.7.) of 8. 1. 17	Disbandment of 640th to 646th ordered by 20/Engrs./5334 (A.G.7.b.) of 24/10/1918.
		,,	641st (Northumbrian) ,, ,, ,, ,, ,,	
		,,	642nd (London) ,, ,, ,, ,, ,,	
		,	643rd (E. Anglian) ,, ,, ,, ,, ,,	
		,	644th (N. Midland) ,, ,, ,,	
		,,	645th (W. Lancs.) ,, ,, ,, ,, ,,	
		,,	646th (London) ,, ,, ,, ,, ,,	
		,,	647th (S. Midland ,, ,, ,, ,, ,,	Disbanded 30. 5. 18. 114/G.N./5763. G.B./4681/A.G.7.
		,,	648th (Home Counties) ,, ,, ,, ,, ,,	France 22. 6. 18 with new 73rd Div.
		,,	649th (W. Riding) ,, ,, ,, ,, ,,	Disbandment ordered by 20/Engrs./5334. (A.G.7.b.) of 24. 10. 18.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Fortress R.E. (T.F.)			
City of Aberdeen W. Co.	1/1 552 (Aberdeen) A.T. Co.	2/1 553 (Aberdeen) Works Co. Disbandment ordered on 20/Engrs./5382 (A.G.7.b.) d. 2. 4. 19.	No 3rd line formed.
City of Dundee No. 1 W. Co. ...	1/1 554th A.T. Co.	2/1 548th (Dundee) was converted from a Fort Co. to a Field Co. for the 71st (Home Service) Div., later the 71st (H.S.) Div. was broken up, but the 548th embarked for N. Russia (Syren Force) on 16. 6. 18. No 2nd line formed for 1/2.	No 3rd line formed.
" " No. 2 E.L. ... (Not pre-war).	1/2 (*Not* pre-war Dundee E.L. Co. Auth. for formation 20/Engrs./5018). (Absorbed (with 1 Sec. of 553rd Works Co., R.E., T.F.) into 590th (Tay and Aberdeen) Fortress Co., R.E. 20/Engrs./5215 (A.G. 7.b.) 10. 6. 18.)		No 3rd line formed.
Renfrew No. 1 Co. (W.)	1/1 406th (Renfrew) Field Co. (Auth. for conversion to Field Co. 79/7634 (A.G.1.) of 22. 6. 15.)	2/1 raised to establ. of 3rd line Depot of a Field Co. on higher establ. as in table "A" of 79/6988 (A.G.1.) of 25. 3. 15. Auth. 79/7634 (A.G.1.) of 22. 6. 15. Later it was merged (with 3/1, 4/2 and 2/3 Highland Field Cos.) into Scottish Group Reserve Field Cos. A.C.I. 2420 of 1916 and designated 408th Highland Reserve Field Co. by 9/Engrs./7611 (A.G.7.) of 8. 1. 17. On reorganization of R.E. Reserves the 408th Field Co. was merged into 6th Reserve Battn., R.E. Irvine. 20/Engrs./5214 (A.G.7.) of 12. 1. 18. The 6th Reserve Battn. has since been reduced to Cadre. 91/Engrs./1311 (A.G.7.b.) of 1. 2. 19 and 18. 2. 19.	No 3rd line formed.
Renfrew No. 2 (E.L.)	1/2 and 2/2 612th Clyde Fortress Co. 20/Engrs./5215 A.G.7.b. of 10. 6. 18. (Prior to reorganization into the 612th Co. the 1/2 and 2/2 were amalgamated with a combined estab. of 14 officers, 200 other ranks. Auth. 79/8344.)	2/2 612th (Clyde) Fortress Co. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18. See note against 1/2.	No 3rd line formed.
City of Edinburgh No. 1 Co. (W.)	1/1 416 Field Co. converted from a Works Co. Auth. 79/7634 (A.G.1.) d. 22. 6. 15.	2/1 raised with Imperial Service *personnel* to the establ. of a 3rd line depôt of a Field Co. on higher establ. (shown in Table A of 79/6988 (A.G.1.) of 29. 3. 15 79/7634 (A.G.1.) of 22. 6. 15. Subsequently absorbed into 418th Lowland Reserve Field Co. See Lowland Dept. R.E.	No 3rd line formed.

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Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
City of Edinburgh No. 2 (E.L.) ... " " No. 3 (E.L.) ... *Not* pre-war. " " No. 4 (E.L.) ... *Not* pre-war. " " No. 5 (E.L.) ... *Not* pre-war.	The 1/2, 2/2, 1/3, 2/3, 1/4, 2/4, 1/5 and 2/5 were absorbed into the 591st and 592nd (Forth) Fortress Cos., R.E. Authority 20/Engrs./5215 A.G.7.b. of 10. 6. 18.	See 1st line.	No 3rd line formed.
Lancashire No. 1 Co. (E.L.) ...	1/1 and 2/1 611th Mersey Fortress Co. Lancs. R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.	2/1 611th (Mersey) Fort. Co. See 1/1.	No 3rd line formed.
" " 2 " (E.L.) ...	1/2 and 2/2 614th (Queenstown) Fort. Co. Lancs. R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18. *Note* :—The 613th (Belfast and Lough Swilly) Fortress Co. was also formed from 1/1, 2/1, 1/2 and 2/2 Lancs. Fort. Cos. R.E., which were reorganised as Nos. 1, 2, and 3 Cos., prior to being numbered 611th, 614th, and 613th Cos.	2/2 614th (Queenstown) Fort. Co. See 1/2.	No 3rd line formed.
" " 3 " (W.) ...	1/3 555th Lancs. A.T. Co.	2/3 549thField Co., converted into a Field Co. for 71st (H.S.) Div. Auth. 79/9368. Later, when the 71st Div. was broken up, this Co. was re-mobilized for the new 73rd Div., and went to France 22. 6. 18.	No 3rd line formed.
Glamorgan No. 1 Co. (W.) ...	1/1 556th A.T. Co.	2/1 550th Field Co. Was converted to a Field Co. for 72nd (H.S.) Div., was known as 72 (Glam.) Field Co., until designated 550th by 9/Engrs./7611 (A.G.7.) of 8. 1. 17. The 72nd (H.S.) Div. was broken up (114/G.N./5763), but the 550th Co. was re-mobilized for new 73rd Div., and went to France 22. 6. 18.	No 3rd line formed.
" " 2 " (W.) ...	1/2 557th A.T. Co.	2/2 551st Field Co. was converted to a Field Co. for 72nd (H.S.) Div., which was broken up. The 551st Co. was disbanded 3. 6. 18 (R.Q. Returns 273 (A.G.7.b.)).	No 3rd line formed.

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R.E., T.F., REORGANISATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Glamorgan No. 3 „ (E.L.) ...	1/3 and 2/3 610th (Milford Haven) Fort Co. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.	2/3 merged with 1/3 into 610th (Milford Haven) Fort. Co. See 1/3.	No 3rd line formed.
„ „ 4 „ (Not pre-war.)	1/4 and 2/4 Not pre-war 609th (Cardiff and Barry) Fort. Co.	2/4 merged with 1/4 into 609th (Cardiff and Barry) Fort. Co. See 1/4.	No 3rd line formed.
„ „ 5 „ ... ... (Not pre-war.)	1/5 Not pre-war 558th Works Co. was formed from portions of 2/1 and 2/2 for Gibraltar 9/Engrs./6139. Went to Gibraltar 29. 10. 16 in replacement of 1/2 Devon (568th A.T. Co.)	No 2/5 formed.	No 3rd line formed.
Tyne Electrical Engrs., R.E., T.F.			
No. 1 Co. (E.L.)	No. 1 Co. was absorbed into 594th (Tyne) Fort. Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.	'The pre-war establishment of the Tyne E.E. is laid down in Peace Establishments Part II., 1914-15. War Establishments Part II., 1911, provided for a Four-Company organization. W.O. letter 79/7634 (A.G.1.), d. 22. 6. 15, authorized the raising of 2nd line units, but no action had been taken to form 2nd line units, and the raising of 2nd line units for the Cos. at Portsmouth was prohibited by 9/Engrs./1784 (A.G.7.) of 14. 9. 15. An increase of 4 officers, 100 other ranks to establishment of Tyne E.E. was approved by 121/6571 (T.F.1.), d. 23. 10. 15, to provide reinforcements for London and Tyne E. and M. Cos. In November, 1915, in view of a proposal to form Field Searchlight detachments for employment in England, a total Establishment for 1st and 2nd lines (at Tyne, Forth, Portsmouth and Isle of Wight) of 64 officers, 1,047 other ranks, was approved by 9/Engrs./1784 (A.G.7.) of 27. 11. 15. In addition to its functions in Garrisons the Tyne E.E. formed various Anti-Aircraft Searchlight Cos. The A.A.S.L. Cos. have since been reorganized as separate units, but the Tyne E.E. and London E.E. are parent units of all R.E. *personnel* attached to A.A. Cos., R.G.A. The establishment of the Tyne E.E. is under consideration on 9/Engrs./8399. The re-formation of T.F. Headquarters has been dealt with on 9/Engrs./8392.	
No. 2 Co. (E.L.)	No. 2 Co. became No. 2 Tyne Searchlight Co., R.E. 9/Engrs./4442 (A.G.7.) of 22. 4. 16. On reorganization of Anti-Aircraft S.L. Cos. it was absorbed into No. 42 A.A.S.L. Co., R.E., which was formed 8. 7. 16 and disbanded 21. 4. 18, the *personnel* being distributed to A.A. Cos., R. G. Artillery. 20/Engrs./5266.		
No. 3 Co. (E.L.)	No. 3 Co. was absorbed into 594th Tyne Fort. Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		
No. 4 Co. (E.L.)	No. 4 Co. became No. 4 Special Tyne Searchlight Co., R.E., 9/Engrs./4442 (A.G.7.) of 22. 4. 16. On reorganization of A.A.S.L. Cos. it was absorbed into No. 34 A.A.S.L. Co., R.E., which was formed 29. 7. 16, and disbanded 26. 1. 18, *personnel* used to form new No. 1 A.A.S.L. Co.		

(*To be continued*).

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PLANE TABLES AND FIELD SHEETS.

By Bt. Lt.-Col. H. St. J. L. Winterbotham, c.m.g., d.s.o., R.E.

In August, 1914, there appeared in the *R.E. Journal* an interesting paper on the subject of mounting drawing paper on plane tables, by Lieut.-Colonel (then Captain) R. H. Phillimore, d.s.o., R.E. The distortion of the "field section" or "field sheet" due to changes of humidity and temperature, has been a thorn in the side of the topographer for many years, neither does there appear to be any means of eliminating it as long as the field sheet is of paper, or Bristol board, mounted upon a wooden board. Some papers give much better results than others. Messrs. Mallandain & Co., King's House, King Street, London, E.C., supplied, before the war, a linen backed paper which has been found to give fairly satisfactory results. Distortion is due, however, not only to the paper, but to the unequal absorption of moisture by the paste, and to differences of expansion in the wood, with and against the grain.

The solution of the problem given by Lieut.-Colonel R. H. Phillimore, is ingenious, and the results of his experience will be most interesting.

An adaptation of the same idea was tried during a topographical training on the Ordnance Survey in 1913. Bristol boards slightly smaller in area than the plane table were attached by corner clips which were kept loose enough to allow free play for expansion except when the plane tabler was actually at work. This system was found to answer fairly well, despite a few cases of "cockling," and made possible the transfer of the Bristol board from the topographers' board to that of the reviser.

In a systematic topographical survey the possibility of transferring a field sheet from one board to another is a great advantage, for it renders unnecessary the number of boards which must otherwise be carried, and enables the plotting of the trig. points to be done as long before the detail as may be expedient.

Bristol boards, however, although they generally show no distortion, if they are free to move, yet do expand. For reproduction this would not be serious, but for the comparison of mutual edges it remains a drawback. Moreover a Bristol board increases the weight. In view of these two objections, experiments were made in

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1913 with linen backed paper mounted on aluminium or zinc. The co-efficients of expansion of both these metals are so small as to be negligible for any ordinary range of temperature.

The points which were aimed at in the production of a mounted field sheet were :—

1. Elimination of distortion.
2. Permanency—so that the finished field sheet should constitute a reliable record of the work done.
3. Adaptability to any of the special plane tables designed for it.
4. Lightness.

The two metals have about equal claims under 1, 2, and 3, but aluminium is much the lighter and its slightly larger cost is negligible in comparison to the value of the finished field sheet. Aluminium was therefore chosen. It was at first thought that the actual field work could be done upon a grained aluminium plate, and the experiment was tried. Although not altogether unsuccessful the experiment proved that an aluminium surface is undesirable for the following reasons :—

1. It is too easily destroyed by dirt and by friction, and will not stand much erasure.
2. It becomes unpleasantly hot in warm weather.
3. It is not easily secured to the table.

Paper can be secured firmly to grained aluminium and the combination remains sensibly constant for normal ranges of temperature. The next experimental field sheet was therefore made of paper pasted or glued to aluminium, but it was found that the edges curled up enough to interfere with the sight rule.

It became necessary, therefore, to strain the field sheet down upon the table by springs, or lashings, and this was simplified by fixing linen on the aluminium with overlaps projecting beyond all four edges. The paper was then mounted on the top of the linen. Field sheets so constructed have proved satisfactory.

The weight of this field sheet is about 1 lb. more than that of linen-backed paper of sufficient size to mount the board. In some surveys this extra 1 lb. would be a handicap, and it seemed possible to save it in the weight of the board. Aluminium (of 30 gauge) supported at small intervals on wooden battens, is sufficiently stiff to bear the weights of the alidade and Indian clinometer, and the pressure of hand and pencil. A skeleton board was therefore made, and proved to answer very well. It is described on page 116 of the "Text Book of Topographical Surveying."

The first design was somewhat too elaborate, however, and during

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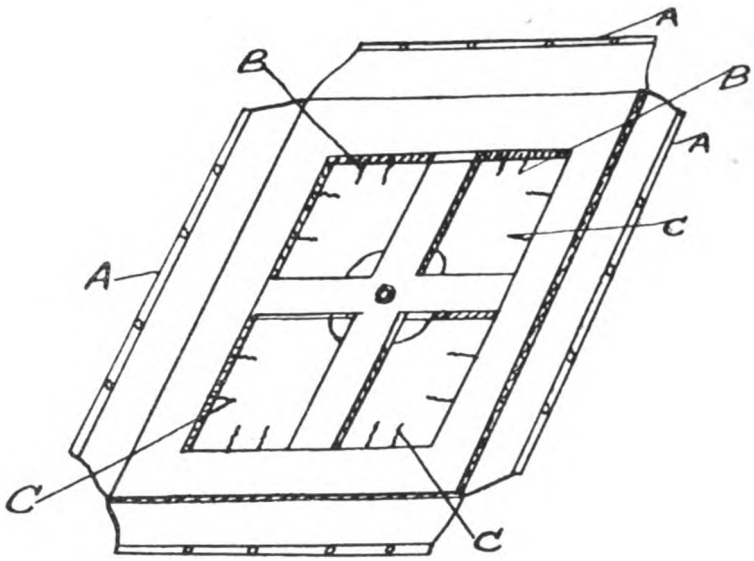
the first trainings of 1914 experiments were made to find a simpler pattern. That which proved most satisfactory is described below.



The field sheet is laid on the board ready for fixing and the board is viewed from below.

A.A. Strips of aluminium mounted in the edge of the overlaps of linen and with holes at intervals to fit.

B.B. Fixed hooks } fixed in the depth of the scantling of the skeleton top.
C.C. Spring hooks }

The weight of this board mounted with an aluminium field sheet is compared with those of a board mounted with linen-backed paper, and a Bristol board, respectively, in the following table :—

Description, size 24 in. by 18 in.	Total Weight.
New board and aluminium field sheet	4 lb. 7½ ozs.
Plane table, R.E.—board with linen-backed paper	4 lb. 12½ ozs.
Plane table, R.E.—board with Bristol board ..	5 lb. 0½ oz.

At the outbreak of war there were only two boards fitted for the new field sheets. Six more of a much larger size (36 in. by 24 in.) were ordered at once, and the whole eight were taken to France by the 1st Ranging Section, R.E.

They proved exceedingly valuable. The original field sheets were used again and again, each successive task, finished in pencil, being rubbed out as soon as it had been traced or photographed.

During the war it was my good fortune to see something of American methods of plane tabling. They differ a good deal from our own, and we had much to learn from each other.

Their field sheets were of a species of grained celluloid, which was

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evidently a first-class surface to work upon. The celluloid was clamped to the board by six saucer-shaped screws which forced the celluloid into corresponding cups in the wooden table. The screw is popularly known as the " blow and be damned " and well deserves its name, for it holds the celluloid securely in any wind, whilst offering no obstacle to the sight rule.

We made some experiments on similar lines and secured fair results, but we found that celluloid expands and contracts and " cockles " a good deal in changeable weather. There is little doubt that the aluminium and paper field sheet is preferable.

The pattern of board described above can be fitted to the legs now in use for the " plane table, R.E."

There are, however, no arrangements for a slow motion in azimuth on these legs. Indeed the feeling of many topographers is averse to the introduction of anything in the nature of a " gadget." In those countries where most of our plane table work is done breakdowns may be fatal. Experiment has proved, however, that a simple but ingenious arrangement can be fitted to the existing pattern of legs which provides a slow motion, thrown in or out of action by a cam, and detachable at will. It was tried in 1914 and unanimously approved of.

Another small modification which proved valuable was the introduction of one collapsible leg for each table. They are quite stiff when clamped, add little to the weight, and enable the table to be levelled on steep ground without undue splay of the legs. As each leg is detachable and is generally packed separate from the " top " the inclusion of a small number of legs of this pattern in the survey outfit will not necessitate their use if found undesirable, but will provide for a probable want.

It occasionally happens that topographical work is based upon a graphic triangulation, or that the two are done concurrently. The importance for graphic triangulation of a field sheet which will maintain its size, not only relatively, but also absolutely, is self-evident. For work of this nature a special plane table has been tried with a board of 24 in. square. The field sheet and board are designed on the same principle as described above, but made stronger to support the additional weight of the telescopic alidade. The board is levelled by a ball and socket joint made of aeromin.

There has been little opportunity, so far, of testing the merits of this board. It has been used for one training only, but was very favourably reported on at that time.

In the following table the 18 in. by 24 in. board designed for a paper-covered aluminium field sheet is called Type " A." The tripod with slow motion in azimuth and one collapsible leg is called Type " A " tripod.

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The larger plane table, 24 in. by 24 in., with ball and socket joint is called Type "B."

Table of Relative Weights and Prices.

N.B.—The prices quoted herein are pre-war prices, and will not apply now.

Description of Table, etc.	Weight. lbs.	ozs.	Price.			Remarks.
Plane table, R.E.—complete (without cover).	10	12½	£2	8	10	Priced vocabulary of stores, Part I.
Type "A" board with tripod of plane table, R.E.	9	7½	£3 £2	0 17	0 6	According to quantity quoted, by Messrs. Watts & Co., 123, Camberwell Road, London.
Type "A" board and Type "A" tripod legs.	11	2½	£3 £3	15 12	0 6	
Type "B" board and tripod.	12	8½	£5 £5	12 7	0 6	

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REVIEW.

PERMANENT WAY HANDBOOK. By Capt. S. C. Clayton, C.E. (late R.E.). (Spon, Ltd.).

One is somewhat misled by the title of this handbook which deals almost exclusively with the practice on Indian Railways and reflects the views of Indian Railway Engineers rather than a general consensus of opinion. To illustrate this one need only quote one example:—The author states that "crossings built of steel rail are superior to any form of cast or box crossing," a view that the vast majority of American railways, and not a few British railways, would contest, if they did not refute. A number of useful formulæ are given for special work, junctions, etc., and some short notes on temporary bridges, painting, brickwork and water supplies.

In the Preface the author suggests that the book should be useful to Permanent Way Engineers and Inspectors—but in order to make it suitable for use by the former, a particular point should be made of distinctly labelling *approximate* formulæ as such. The formula given on pp. 34—35 is an example, where under certain circumstances a very considerable accumulated error will be produced on a long curve. Incidentally the diagram illustrating this method should be re-drawn in accordance with the letter-press. There is some discrepancy in the figures given for expansion gaps at rail ends for 30-ft. rails—*vide* $\frac{1}{4}$in. on page 10, and $\frac{3}{8}$in. on page 23.

If the book is to be of general utility it would be advisable to add a glossary of terms, for the engineer who works with flanged rail might be puzzled at the note that "the nose of the switch rails should be neatly housed under the flange (*sic*) of the stock-rail."

Speaking broadly, the book should be of value to P.W. Inspectors in the country where the practice quoted in it obtains, but very considerable revision and widening of its views would be necessary before it could be claimed to be of general utility.

H. N. Cotterill, *Capt., R.E.*

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BOOKS ON ENGINEERING.

THE following is a list of books which are recommended to officers who wish to improve their knowledge in various branches of engineering.

The list is not complete, but will be republished with additions and amendments from time to time.

Should an officer require information on any subject not included in these lists, he should write direct to the Chief Instructor in Construction, S.M.E., Chatham, stating as fully as necessary what his requirements are, and every endeavour will be made to supply or procure the information.

1. APPLIED MECHANICS.

NOTES ON APPLIED MECHANICS. (Printed at the S.M.E.).

THE STRENGTH AND ELASTICITY OF STRUCTURAL MEMBERS.—By R. J. Woods, M.Inst.C.E. Published by Edward Arnold, London. 2nd edition; 1 vol.; 8vo. 1906. 10/6.

Chapter I.—Graphic Statics. II.—Stress and Strain. III.—Stress-Strain Diagrams, Working Stress, Resilience. IV.—Compound Stresses. V.—Bending Moments and Shearing Forces. VI.—Moments of Inertia. VII.—Girders. VIII.—Deflections. IX.—Combined Stress, Non-Axial Stress, Stress at a Plane Joint, Masonry Structures. X.—Columns and Struts. XI.—Riveted Joints. XII.—Continuous Girders. XIII.—Cantilever Bridges, Suspension Bridges, Arched Ribs. XIV.—Torsion.

This book was originally written as a series of lectures for students at the Royal Indian Engineering College, Cooper's Hill. It is a clearly written elementary text book.

THE THEORY OF STRUCTURES.—By R. J. Woods, M.Inst.C.E. Published by Edward Arnold, London. 1 vol.; 8 vo.; 1909. 10/6.

Chapter I.—Compound and Principal Stresses. II.—Earth Pressure. III.—Stresses due to Eccentric Loads. IV.—Working Stresses, Stresses in Girders with Parallel Chords by Method of Co-efficients. V.—Girders with Parallel Chords, General Method. VI.—Parabolic Girders. VII.—Curved Girders, not Parabolic. VIII.—Wind Pressure, Portal Bracing, High Steel Trestles. IX.—Continuous Girders. X.—Cantilever Girders, Suspension and Stiffening Girders. XI.—Riveted Joints. XII.—Plate Girders. XIII.—Columns and Struts. XIV.—Arched Ribs and Braced Arches. XV.—Reinforced Concrete.

This volume is a continuation of "The Strength and Elasticity of Structural Members," by the same author. It contains several worked out examples but no drawings of actual work.

THE THEORY AND DESIGN OF STRUCTURES.—By E. S. Andrews, Lecturer at the Goldsmiths' College, New Cross. Published by Chapman & Hall, London. 1 vol.; 8 vo.; 1908. 9/-

Chapter I.—Stress, Strain, and Elasticity. II.—Principles of Design. Working Stress, Wind Pressure. III.—Forces, Areas, Moments. IV.—Riveted Joints. V.—Bending Moments and Shearing Forces. VI.—Stresses in Beams. VII.—Rolling Loads. VIII.—Deflection. IX.—Fixed and Continuous Beams. X.—Shearing Stress in Beams. XI.—Framed Structures. XII.—Columns and Struts. XIII.—Suspension Bridges and Arches. XIV.—Masonry Structures. XV.—Reinforced Concrete. XVI.—Design of Steelwork in Buildings. XVII.—Design of Roofs. XVIII.—Design of Bridges and Girders.

This book covers the usual college course, and is good of its kind, but only touches lightly on questions of design. The diagrams and general presentation are good.

APPLIED MECHANICS.—Embracing the Strength and Elasticity of Materials, Theory and Design of Structures, Theory of Machines and Hydraulics. By D. A. Low, M.I. Mech. E., Professor of Engineering, East London College. Published by Longmans, Green & Co., London. 1 vol.; 8 vo.; 1913. 7/6.

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Chapter I.—Preliminary. II.—Motion and Force. III.—Work and Energy. IV.—Polygon of Forces. V.—Moments and Centroids. VI.—Simple Strains and Stresses. VII.—Beams and Bending. VIII.—Deflection. IX.—Compound Strains and Stresses. X.—Columns and Struts. XI.—Behaviour of Materials in the Testing Machine. XII.—Stress Diagrams. XIII.—Design of Roofs. XIV.—Design of Plate Girders. XV.—Design of Braced Girders. XVI.-XXVI.—Theory of Machines. XXVII.—Hydrostatics. XXVIII.-XXXI.—Hydraulics.

Only a portion of this book is devoted to structural mechanics. This covers the ordinary college course. There are three chapters on design, including worked out examples of plate and braced girders, with detailed drawings. The book makes a feature of exercises, of which there are 780 in all.

GRAPHICS AND STRUCTURAL DESIGN.—By H. D. Hess, M. Amer. S.C.E., Professor of Machine Design, Cornell University; formerly Designer and Compiler with the American Bridge Company. Published by Wiley & Sons, New York (Chapman & Hall, London). 1 vol.; 8 vo. 2nd edition, 1916, $3·00.

Chapter I.—Materials. II.—Graphics. III.—Stresses in Structures. IV.—Algebraic Determination of Stresses. V.—Influence Diagrams. VI.—Tension Pieces, Compression Pieces, and Beams. VII.—Columns. VIII.—Girders for Conveyors. IX.—Trusses, Bents, and Towers. X.—Design of Steel Mill Buildings. XI.—Design of a Plate Girder Railway Bridge. XII.—Crane Frames. XIII.—Girders for Overhead Electric Travelling Cranes. XIV.—Reinforced Concrete. XV.—Foundations. XVI.—Chimneys. XVII.—Retaining Walls. XVIII.—Bins. XIX.—Shop Floors. XX.—Walls and Roofs. XXI.—Specifications. XXII.—Problems.

2. MATHEMATICS.

CALCULUS FOR ENGINEERS.—By Prof. Perry. Published by Edward Arnold. 7/6.

A most useful and interesting book, giving progressive examples of the practical application of the Calculus to Engineering and Electrical problems.

Unlike most other treatises on the Calculus, this book is essentially practical from beginning to end.

STRENGTH OF MATERIALS.

THE STRENGTH OF MATERIALS.—By J. A. Ewing, F.R.S., M.Inst.C.E., etc. Cambridge University Press.

Chapter I.—Stress and Strain. II.—Relation between the Elastic Constants. III.—Ultimate Strength and Non-elastic Strain. IV.—Testing of Materials. V.—Uniform and Uniformly Varying Distributions of Stress. VI.—Stress in Beams. VII.—Deflection of Beams. VIII.—Frames. IX.—Struts and Columns. X.—Torsion of Shafts. XI.—Shells and Thick Cylinders. XII.—Hanging Chains and Arched Ribs.

STRENGTH OF MATERIALS.—By Arthur Morley, M.I. Mech. E., formerly Professor of Mechanical Engineering in University College, Nottingham. Published by Longmans, Green & Co., London. 1 vol.; 8 vo.; 3rd edition; 1913. 7/6.

Chapter I.—Elastic Stress and Strain. II.—Mechanical Properties of Metals. III.—Resilience and Fluctuating Stress. IV.—Theory of Bending. V.—Stresses in Beams. VI.—Deflection of Beams. VII.—Built-in and Continuous Beams. VIII.—Secondary Effects of Bending. IX.—Direct and Bending Stresses. X.—Twisting. XI.—Pipes, Cylinders, and Discs. XII.—Bending of Curved Bars. XIII.—Flat Plates. XIV.—Vibrations and Critical Speeds. XV.—Testing Machines, Apparatus, and Methods. XVI.—Special Tests. XVII.—Special Materials.

THE ELASTICITY AND RESISTANCE OF THE MATERIALS OF ENGINEERING.—By W. H. Burr, C.E., Professor of Civil Engineering, Columbia University, New York. Published by Wiley & Sons, New York (Chapman & Hall, London). 1 vol.; 8 vo.; 7th edition, 1916. $5·50.

Part I.—Analytical. Elementary Theory of Elasticity in Amorphons; Solid Bodies; Flexure; Torsion; Hollow Cylinders and Spheres; Resilience; Combined Stress Conditions.

Part II.—Technical. Tension, Compression; Riveted Joints and Pin Connections; Long Columns; Shearing and Torsion; Bending or Flexure; Concrete—Steel Members; Rolled and Cast-Flanged Beams; Plate Girders; Miscellaneous Subjects; The Fatigue of Metals; The Flow of Solids.

Appendix I.—General Equations; Thick Hollow Cylinders and Spheres; and Torsion; Theory of Flexure.

Appendix II.—Clavareno's Formulæ.

Appendix III.—Resisting Capacity of Natural and Artificial Ice.

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3. STRUCTURAL STEEL.

ENGINEERING CONSTRUCTION IN STEEL AND TIMBER.—By W. H. Warren, M.Inst.C.E., Challis Professor of Engineering, University of Sydney. Published by Longmans Green & Co. Price 18/-.

Chapter I.—Stress, Strain, Working Stresses: Properties of Steel. II.—Timber and its Properties. III.—Determination of the Stresses in Structures. IV.—Bending Moments and Shearing Stresses. Influence Lines. V.—Moments of Resistance and Intensity of Shearing Stresses in Beams. VI.—Bridges and Viaducts of Small Span. VII.—Examples of Graphical Statics. VIII.—Braced Girders with Parallel Chords. IX.—Bowstring and other Trusses. X.—Slope and Deflection of Beams. XI.—Continuous and Cantilever Bridges. XII.—Strength of Columns. XIII.—Riveted Joints. Pins and Eye-Bars in Bridges. Timber Joints. XIV.—Wind Pressures etc. XV.—Stresses in Braced Piers. XVI.—Approximate Weights of Girders and Trusses. Live Loads. Concentrated Wheel Loads. XVII.—Plate Web Girder Bridges. XVIII.—Pratt Truss Bridges. XIX.—Design of a Parker Truss Bridge for a Single Line of Railway. XX.—Swing Bridges. XXI.—Arched and Suspension Bridges.

THE DESIGN OF STEEL MILL BUILDINGS AND THE CALCULATION OF STRESSES IN FRAMED STRUCTURES.—By M. L. Ketchum, C.E., Professor of Civil Engineering, Colorado University, Consulting Engineer. Published by Engineering News Publishing Co., New York. 1 vol., 8 vo.; 3rd edition; 1913. $4·00.

Part I.—Loads. Chapters I.-IV.—Dead, Snow, Wind, and Miscellaneous Loads.

Part II.—Stresses. Chapter V.—Graphic Statics. VI.—Stresses in Framed Structures. VII.—Stresses in Simple Roof Trusses. VIII.-IX.—Beams. X.—Stresses in Bridge Trusses XI.—Stresses in a Transverse Bent. XII.—Stresses in Portals. XIII.—Stresses in a Three-Hinged Arch. XIV.—Stresses in a Two-Hinged Arch. XV.—Combined and Eccentric Stresses. XVI.—Graphic Calculation of Deflection in Beams.

Part III.—Design of Mill Buildings. Chapter XVI.—General Design. XVII.—Framework. XVIII.—Corrugated Steel. XIX.—Roof Coverings. XX.—Side Walls and Masonry Walls. XXI.—Foundations. XXII.—Floors. XXIII.—Windows and Skylights. XXIV.—Ventilators. XXV.—Doors. XXVI.—Shop Drawings and Rules. XXVII.—Paints and Painting. XXVIII.—Estimates of Weight and Cost.

Part IV.—Miscellaneous Structures. Description of various Buildings, Specifications, Problems in Graphic Statics and Calculations of Stresses.

"The book is intended to provide a short course in the calculation of stresses in framed structures and to give a brief discussion of steel mill construction. It is meant to supplement the elementary books on stresses on the one hand and the more elaborate treatises on bridge design on the other. Much of the matter will apply equally well to all classes of steel frame construction." The author has a large consulting practice and considerable teaching experience. The book is well illustrated and there are several worked out examples.

STRUCTURAL ENGINEERS' HANDBOOK. Data for the Design and Construction of Steel Bridges and Buildings.—By M. L. Ketchum, C.E., Professor of Civil Engineering, University of Colorado, Consulting Engineer. Published by McGraw Hill Book Co., New York (Hill Publishing Co., London). 1 vol.; 8 vo.; 1914. $5·00.

Part I.—Data and Details for Design and Construction. Chapter I.—Steel Roof Trusses and Mill Buildings. II.—Steel Office Buildings. III.—Steel Highway Bridges. IV.—Steel Railway Bridges. V.—Retaining Walls. VI.—Bridge Abutments and Piers. VII.—Timber Bridges and Trestles. VIII.—Steel Pins. IX.—Steel Grain Elevators. X.—Steel Head Frames and Coal Tipples. XI.—Steel Stand Pipes and Elevated Tanks. XII.—Structural Drafting. XIII.—Estimates of Structural Steel. XIV.—Erection of Structural Steel. XV.—Engineering Materials. XVI.—Structural Mechanics. XVII.—The Design of Steel Details.

Part II.—Structural Tables.—This part consists of 165 tables under the following headings:—Bars and Plates, I Beams, Channels, Angles, Miscellaneous Sections, Columns and Struts, Top Chord Sections, Plate Girders, Details for Bars, Pins, Bolts and Nuts, Rivets and Riveting, Beam and Lateral Connections, Miscellaneous, Bethlehem Sections, Mathematical, and Miscellaneous.

"This book"—to quote the preface—" is for the student or engineer who has had a thorough course in applied mechanics and the calculations of stresses in structures. Great care has been used to give examples that represent standard practice. The drawings have been prepared from actual working plans. The book is a source book, not a treatise, intended to furnish data that are available to only a few engineers, and specifications that are available only in transactions of societies or special treatises." Though dealing with American practice this is a very useful up-to-date book. Part I, 600 pp., contains a mass of information on practical calculations, specifications, structural details, materials, etc., and is profusely illustrated.

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4. STRUCTURAL TIMBER.

STRUCTURAL DETAILS: ELEMENTS OF DESIGN OF TIMBER FRAMING.—By H. S. Jacoby, Professor of Bridge Engineering, Cornell University. Published by Wiley & Sons, New York. 1 vol.; 8 vo.; 1914. 9/6.

Chapter I.—Fastenings. II.—Joints. III.—Wooden Beams and Columns. IV.—Wooden Roof Trusses. V.—Examples of Framing in Practice. VI.—Timber Tests and Working Stresses.

A very useful book on the designing of timber work, with much information on the strength of nails and bolts and the strength of joints. Well illustrated with dimensioned drawings. The book is frequently quoted in the United States.

TIMBER FRAMING.—By H. D. Dewell, Assoc. M. Amer. S.C.E., Chief Structural Engineer for the Panama-Pacific International Exposition. Published by Dewey Publishing Co., San Francisco (D. Van Nostrand & Co., New York). 1 vol.; 8 vo.; 1917. 10/-.

Chapter I.—Introduction. II.—Mill and Yard Specifications, Grading Rules. III.—Working Stresses. IV.—Washers and Pins; Compression on Surfaces Inclined to the Direction of the Fibres; Resistance of Wood to Metal Pins; Sheer Pin Joints. V.—Spiked, Screwed, and Bolted Joints; Lateral Resistance of Spikes and Nails, Common Wood Screws, Lag Screws, and Bolts. VI.—End Joints. VII.—Intermediate Joints. VIII.—Tension and Compression Splices. IX.—Main Members of Trusses, Compression Chords and Struts, Laminated Truss Chords, Timber Tension Members, Tension Rods. X.—Bracing Trusses: Details of Howe Roof Truss, Lattice Trusses, Truss Connections to Posts. XI.—Theory of Columns: Tests of Timber Columns. XII.—Column Splices and Girder Connections; Floors: Joists; Joist Hangers; Mill Construction. XIII.—Foundations. XIV.—Miscellaneous Structures. XV.—Wind Pressure: Working Drawings. XVI.—Specifications for Timber Framing.

An up-to-date book treating fully and practically a subject which is hardly discussed at all in other books, with the exception of the previous one by H. S. Jacoby. The author has had eleven years' experience of timber work on a large scale.

5. STEEL BRIDGES.

DESIGN OF STEEL BRIDGES.—By F. C. Kunz, C.E., formerly Designer for the Bridge and Construction Department of the American Bridge Company and Chief Engineer of the Bridge and Construction Department of the Pennsylvania Steel Company. Published by McGraw Hill & Co., New York (Hill Publishing Co., London), 1 vol.; 8 vo.; 1915. 21/-.

Chaper I.—External Forces. II.—Reactions and Influence Lines. III.—Moments and Shears in Simple Spans. IV.—Stresses in Simple Trusses. V.—Stresses in Bracing of Simple Spans. VI.—Types of Bridges and Principal Dimensions. VII.—Design of Bridge Floors. VIII.—Beam and Plate Girder Bridges. IX.—Simple Truss Bridges. X.—Skew Bridges and Bridges on Curves. XI.—Weights of Simple Span Bridges. XII.—Viaducts. XIII.—Elevated Railroads. XIV.—Movable Bridges and Turntables. XV.—Arch Bridges. XVI.—Long Span Bridges in General and Examples. XVII.—Cantilever Bridges.

Appendix A.—Actual Pressure of Foundations in Bridge Work. B.—Actual Pressure of Foundations in Structural Work. C.—Properties of Materials. D.—Tables. E.—Properties of Sections. F.—Riveting. G.—Tables. H.—Specifications.

This book was to form the second volume of a series all by the same author, but so far it is the only one publisned. The first, third, and fourth volumes were to deal with General Theory, Steel Buildings, and Masonry, Concrete, and Reinforced Concrete, respectively.

The book is written in a somewhat condensed style. Its aim is not to be a text book, but to give the engineer numerical examples and results of the best modern practice in designing and estimating of steel bridges, and to serve him as a guide and aid in the calculation of stresses, sections, and weights. A feature is the set of 52 good plates at the end of the book, "which are expected to guide the designer from dead and live load assumptions to the last rivet spacing without reference to the text."

BRIDGE ENGINEERING.—By J. A. L. Waddell, C.E., D.Sc. Published by Wiley & Sons, New York (Chapman & Hall, London). 2 vols.; 8 vo.; 1916. $10·00.

Volume I.—Chapter I.—Evolution of Bridge Engineering. II.—The Bridge Specialist. III.—Ordinary Materials of Bridge Construction. IV.—Alloy Steels in Bridge Work. V.—Dead Loads. VI.—Live Loads. VII.—Impact Loads. VIII.—Centrifugal Force and Other Effects of Track Curvature. IX.—Wind, Vibration,

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and Traction Loads. X.—Methods of Stress Computation. XI.—Secondary Temperature and Indeterminate Stresses. XII.—Deflections. XIII.—Combination of Stresses. XIV.—Intensities of Working Stresses. XV.—First Principles of Designing. XVI.—Detailing in General. XVII.—Shopwork as Affecting Bridge Design. XVIII.—Classes of Traffic and Provision Therefor. XIX.—Floors and Floor Systems. XX.—Laterals and Sway Bracing. XXI.—Plate Girder and Rolled I Beam Bridges. XXII.—Simple Truss Bridges. XXIII.—Trestles, Viaduct, and Bridge Approaches. XXIV.—Elevated Railroads. XXV.—Cantilever Bridges. XXVI.—Arch Bridges. XXVII.—Suspension Bridges. XXVIII.—Movable Bridges in General. XXIX.—Swing Bridges. XXX.—Bascule Bridges. XXXI.—Vertical Lift Bridges. XXXII.—Riveted *versus* Pin-Connected Trusses. XXXIII.—Dimensioning for Camber. XXXIV.—Protection of Metal Work. XXXV.—Wooden Bridges and Trestles. XXXVI.—Draw Bridges and Protection. XXXVII.—Reinforced Concrete Bridges. XXXVIII.—Foundations in General. XXXIX.—Cofferdams. XL.—Open Dredging Process. XLI.—Pneumatic Process. XLII.—Piles and Pile Driving. XLIII.—Piers, Pedestals, Abutments, Retaining Walls, and Culverts. XLIV.—Shore Protection and Mattress Work.

Volume II.—Chapter XLV.—Expedients in Design and Construction. XLVI.—Data Required for Designing Bridges, Trestles, and Viaducts. XLVII.—Locating of Bridges and Preliminary Surveys. XLVIII.—Borings. XLIX.—Determination of Waterways. L.—Requirements of the U.S. Government for Bridging Navigable Waters. LI.—Hydrographic Surveys for the Bridging of Navigable Waters. LII.—Æsthetics in Design. LIII.—True Economy in Design. LIV.—Determination of Lay-Outs. LV.—Weights of Steel Superstructures. LVI.—Quantities for Piers, Pedestals, Abutments, Retaining Walls, and Reinforced Concrete Bridges. LVII.—Estimates. LVIII.—Office Practice. LIX.—Inspection of Materials and Workmanship LX.—Triangulation. LXI.—Engineering of Construction. LXII.—Erection and Falsework. LXIII.—Maintenance of Traffic. LXIV.—Bridge Examination. LXV.—Reconstruction, Maintenance, and Repair of Existing Bridges. LXVI.—Status of Highway Bridge Building. LXVII.—Bridge Failures and Their Lessons. LXVIII.—Specifications in General. LXIX.—Contracts. LXX.—Reports. LXXI.—Administration of Construction. LXXII.—Arbitration. LXXIII.—Promotion of Bridge Projects. LXXIV.—Bridge Engineering Fees. LXXV.—Some Business Features of Bridge Engineering. LXXVI.—Responsibility of the Bridge Engineer. LXXVII.—Ethics of Bridge Engineering. LXXVIII.—General Specifications Governing the Design of Superstructure of Bridges, Trestles, Viaducts, and Elevated Railroads. LXXIX.—General Specifications for Manufacture and Erection of Superstructure, Substructure, and Approaches, etc. LXXX.—Glossary of Terms (243 pp.). Index (224 pp.).

This is a very valuable book, and well worth reading even by other than bridge engineers, for many of the chapters are interesting essays in themselves. The book is written in an almost conversational style, with many touches of personal experience which make it very readable. The author, who is a well-known American consulting engineer, states his aim to be " to give to his readers, concerning every branch of bridge work, all the information he has been able to accumulate during a practice of 40 years. Nothing of any value has been omitted, except such matter as can readily be obtained from other books, because he has never been a believer in the pseudo-economic idea that what has cost so much labour and money to discover and record should be utilised only for one's personal gain. On that account there appear for the first time in print all the diagrams of weights of metals, quantities of masonry, costs of construction, economic functions, etc., that this book contains."

The book has been very favourably received. It contains 2,200 pages, including a useful glossary of 243 pages, a full index, and very many plans, diagrams, and tables.

6. CONCRETE AND REINFORCED CONCRETE.

REINFORCED CONCRETE.—By Capt. J. G. Fleming, R.E. Published by the R.E. Institute. Price 3/6. (Out of Print).

A revised and enlarged edition will be issued early next year.

REINFORCED CONCRETE CONSTRUCTION, Part I.—By M. T. Cantell (Spon & Co.). A somewhat elementary, but excellent little book, giving a full table of formulæ, and 30 worked out examples of columns, singly and doubly reinforced beams and Tee Beams.

CONCRETE ENGINEERS' HANDBOOK.—Data for the Design and Construction of Plain and Reinforced Concrete Structures.—By G. A. Hool, N. C. Johnson, and S. C. Hollister. Published by MacGraw, Hill Book Co., New York (Hill Publishing Co, London). 1 vol.; 8 vo.; 1918. 25/-.

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PRINCIPLES OF REINFORCED CONSTRUCTION.—By F. E. Turneaure, Dean of the College of Engineering, Wisconsin University, and E. R. Maurer, Professor of Mechanics, Wisconsin University. Published by Wiley & Sons, New York (Chapman & Hall, London). 1 vol.; 8 vo.; 2nd edition; 1909. 15/-.

Chapter I.—Introductory. II.—Properties of the Material. III.—General Theory. IV.—Tests of Beams and Columns. V.—Working Stresses and General Constructive Details. VI.—Formulæ, Diagrams and Tables. VII.—Building Construction. VIII.—Arches. IX.—Retaining Walls and Dams. X.—Miscellaneous Structures. XI.—Chimneys.

MANUAL OF REINFORCED CONCRETE AND CONCRETE BLOCK CONSTRUCTION.—By C. F. Marsh, M.I.C.E., and W. Dunn, F.R.I.B.A. Published by Constable & Co., London. 1 vol.; 8 vo., pocket size; 3rd edition; 1916. 10/6.

Part I.—Materials. II.—Construction. III.—Waterproofing and Fire Resistance. IV.—Loads, Bending Moments, etc. V.—Calculations. VI.—Hollow Concrete Blocks. VII.—Tables, Diagrams, and General Information.

Gives in handy form the methods employed for the solution of everyday problems, with the information most frequently required in as condensed form as possible consistent with clearness. Demonstration and reasoning upon which formulæ are based are mostly omitted. Practical construction is fully dealt with. There are numerous labour-saving tables. Strongly recommended.

CONCISE TREATISE ON REINFORCED CONCRETE.—A companion to "The Reinforced Concrete Manual." By C. F. Marsh, M.Inst.C.E., and W. Dunn, F.R.I.B.A. Published by Constable & Co., London. 1 vol.; 8 vo.; 1909. 7/6.

Chapter I.—Properties. II.—Behaviour under Loading. III.—Assumptions for Calculation. IV.—Methods of Calculation. V.—Methods of Reinforcement.

This supplements the "Manual," matters dealt with there being mostly omitted from this book, while the derivation of fundamental formulæ is fully explained.

CONCRETE, PLAIN AND REINFORCED.—By Taylor and Thompson. Published by Chapman and Hall, Ltd. Deals with the materials, construction, and design of Concrete and Reinforced Concrete.

Chapter I.—Essential Elements. Data on Handling Concrete Labour, Costs of Hand Mixing, Weights and Volumes. II.—Selection of Materials, Proportions, Quantities, Tools and Apparatus, Construction of Forms, Mixing and Laying, Cost and Strength of Concrete. III.—Specification for Reinforced Concrete. IV.—Classification of Cements. V.—Chemistry of Hydraulic Cements. VI.—Specification of Tests of Cement. VII.—Tests of Aggregate. VIII.—Voids and other Characteristics of Concrete Aggregates. IX.—Strength of Composition of Cement Mortar. X.—Preparation of Materials for Concrete. XI.—Tables of Quantities. XII.—Preparation of Concrete. XIII.—Mixing Concrete. XIV.—Depositing Concrete. XV.—Effect of Sea-water. XVI.—Laying Concrete during Frost. XVII.—Destructive Agencies. XVIII.—Water Tightness. XIX.—Strength of Plain Concrete. XX.—Theory of Reinforced Concrete. XXI.—Tests of Reinforced Concrete. XXII.—Design. XXIII.—Building Construction. XXIV.—Foundations of Piers. XXV.—Beam Bridges. XXVI.—Arches. XXVII.—Dams and Retaining Walls. XXVIII.—Conduits of Tunnels. XXIX.—Reservoirs and Tanks. XXX.—Pavements and Side-walks. XXXI.—Cement Manufacture.

This book is especially valuable but the methods of Design of Reinforced Concrete given in Chapter XXII. are not of such universal application as those given by Marsh and Dunn in their Manual of Reinforced Concrete. The author very clearly explains in Chapter XX. and Chapter XXI. certain much valuable information of Tests of Reinforced Concrete.

WATER SUPPLY.

WATER SUPPLIES: THEIR PURIFICATION, FILTRATION AND STERILIZATION.—By S. Rideal. Published by Crosby, Lockwood & Sons. 1914. Price 7/6.

Chapter I.—Pure Water—Inorganic Constituents of Natural Waters. II.—Animal and Vegetable Impurities. III.—Sources of Water Supply. IV.—Distribution. V.—Storage. VI.—Preliminary Purification. VII.—Sand Filtration. VIII.—Mechanical Filtration. IX.—Softening of Water. X.—Sterilization. XI.—Electrical Modes of Sterilization. XII.—Analysis and Interpretation of Results.

An up-to-date book on the subject. It is clearly and concisely written, and at the same time gives very complete information.

Copies of the books mentioned in this article are being placed in the R.E. Library, Horse Guards, S.W.1.—ED. R.E.J.

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NOTICES OF MAGAZINES.

THE MILITÄR-WOCHENBLATT.

July—August, 1919.

The paper seems to be drifting more and more into being the organ of the ex-officer; much of its contents is taken up with articles on the economic position of officers and ex-officers, regimental unions, notices of civil posts open to officers (mostly in police and municipal services). The translation of Lord French's "1914" is continued in each number, as are also "Reviews of the Press," wholly from English papers, and "Short Notices," paragraphs of military news from the Entente Press. "The Rolls of Honour" still form an interesting feature: noticeable are the small losses of the cavalry. (A few numbers of the paper during the period July—August, 1919, were not received).

No. 10.

The Officers' Compensation Law.—A complaint that the War Ministry has not listened to the demands of the D.O.B., the German Officers' Union.

Remarks on the Military Political Situation in Russia.

Provision for the Military who are to be retired from the Army.—As the Army has to be reduced to 100,000 by the 1st April, 1920, the officers, who before the war numbered 36,000, will be cut down to 4,000, and jobs must be found for the N.C.O.'s, 76,000 strong before the war. In the present state of unemployment and credit, their prospects are poor and the State must provide for them. (In the advertisements three situations only for ex-officers appear.)

Roll of Honour.—Infantry Regiment No. 146: officers 85, N.C.O.'s 232 and 1,960 men killed. Infantry Regiment No. 149: officers 122, other ranks 3,446 killed. Pioneer Battalion No. 5: officers 56, N.C.O.'s 167, men 1,045 killed. Hussar Regiment No. 8: 35 officers and many other ranks killed.

Advertisements.—Announce the formation of a number of Regimental Clubs.

No. 11.

The Officers' Compensation Law.—A bitter complaint at the treatment of officers under the peace terms. What would happen it is asked if 16,000 railway or post office employés were suddenly turned out into the street. The terms of compensation proposed for officers removed on reduction of establishment are:—(*a*) Officers under 10 years' service, one year's pay without allowances. (*b*) All other officers up to Brigade-

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Commanders exclusive, if married, 5 years' pay; if unmarried, 2 years' pay. (*c*) Brigade-Commanders and upwards will receive pensions.

"*Long-continued Laughter from the Whole House.*"—A complaint that the above appears in an account of a sitting of the Reichstag. "There ought" the writer says, "to be tears and gnashing of teeth."

Officers' Settlement Union.—This Union has taken a piece of ground to teach ex-officers and officials agriculture and gardening.

Rolls of Honour.—Infantry Regiment No. 97: 120 officers and about 3,000 other ranks killed. Infantry Regiment No. 98: 90 officers and 2,245 other ranks killed.

Advertisements.—A Union to protect the personal freedom and life of Wilhelm II. has been formed. Warning against migrating to Cassel, as there is a lack of houses there.

No. 12.

Misleading Generalizations.—A signed article by the well-known military historian General von Freytag-Loringhoven denouncing two books:—"The Death Path of the German Army" and "The Marne Drama" (reviewed in the *Times Literary Supplement* of 4th September), in which the truth about the condition of the German Army in the latter part of 1918 is told.

Bonus for Retired Officers on Account of Dearness of Living.—Complaints that the instructions are not clear and smell of the Finance Branch—A poor War Ministry defence follows.

Roll of Honour.—Uhlan Regt. No. 14: 20 officers and many other ranks killed.

Advertisements.—The Mess furniture, etc., of the Military Technical Academy (where Engineer and Artillery officers received higher technical training), and of the Non-Commissioned Officers' School at Treptow are being sold off. So the schools are no doubt being closed down. Five posts in municipal offices and police are offered to ex-officers.

No. 14.

Transfer of Officers in the Active Army.—In selecting officers for the Defence Force, their confidential reports, their behaviour in war and since the armistice, age, size of family and private means will be taken in account.

The Officers' Compensation Law.—A complete draft of the bill, the important points of which were given in No. 13, is printed.

Our South Russian Troops.—A bitter complaint of the treatment by the Allies of the German Forces cut off in South Russia. They could not march home, the Allies promised ships, but only took the troops as far as Salonika, where they were interned. The senior officer who made complaints was given 15 days' arrest by the French Commander.

The War Minister to General Otto von Below.—A letter of official thanks for services. It is quite a good imitation of the ex-Kaiser's best style.

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Regimental Unions of the Old Army.—A further list of unions formed.

Roll of Honour.—The Guard Corps Train : 18 officers and many other ranks killed.

No. 15.

Proposals for State Assistance to Pensioners remaining in Ceded Territory.—Apparently pensioners who remain in Alsace and Lorraine, etc., at present are deprived of their pensions.

Not Black-red-gold, rather Black-white.—The proposed democratic national colours are jeered at. If black-red-white will not do, then it is better to adopt the Prussian colours, black and white.

Posts for ex-Officers.—Seven police and municipal jobs are offered. The pay varies from 2,400 to 6,000 marks.

Rolls of Honour.—Foot Artillery Regiment No. 7 : 64 officers and over 1,000 other ranks killed. Fusilier Regiment No. 33 : 101 officers and 3,000 other ranks killed. Infantry Regiment No. 143 : 121 officers, 324 N.C.O.'s and 2,619 men killed.

No. 16.

Ludendorff's Memorandum of September, 1917.—A violently worded article denying that the chance of peace in 1917 was spoilt by Ludendorff demanding enormous annexions. Far from it, the published documents show that he only wanted the Briey plateau, a more favourable frontier on the Meuse, and a commercial connection with Belgium that would ensure the necessary facilities for expansion to German trade !

The Officers' Compensation Law.—A later complete text of the bill. The amounts proposed are slightly less than before published, and officers must have done 12 years' service instead of 10 before they receive any compensation for being compulsorily retired.

Rolls of Honour.—Infantry Regiment No. 29 : 143 officers and about 3,500 other ranks killed. Infantry Regiment No. 74 : 101 officers, 310 N.C.O.'s and 2,236 men killed.

No. 17.

The Strength and Worth of our Future Peace Army.—By the peace conditions Germany is allowed a maximum of 100,000 men, insufficient, the writer says, to maintain internal order. He disapproves of the proposed organization of the 100,000 allowed, viz., Staffs 1,696, Infantry 53,046, Cavalry 16,212, Artillery 10,955, Pioneers 2,884, etc., on the ground that over one-sixth are Cavalry ; before the war, in which Cavalry did nothing, the proportion was one-tenth. He suggests cutting down the Cavalry by half and doubling the Artillery, and increasing the Pioneers to 3,200 and adding a Flying Corps.

The Fate of our Fortresses.—Twenty are to be ceded or destroyed, and there will only remain Borkum, Cüstrin, Cuxhaven, Geestemünde, Glatz, Glogau, Ingolstadt, Königsberg, Königstein, Neisse, Pillau, Spandau, Swindemünde, Ulm, Wilhelmshafen.

Rolls of Honour.—Infantry Regiment No. 141 : 120 officers killed.

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Infantry Regiment No. 96: 114 officers killed; in 1914, 26; in 1915, 26; in 1916, 12; in 1917, 16; and in 1918, 31, and 3 unknown. Infantry Regiment No. 112: 87 officers, 281 N.C.O.'s and 2,462 men.

No. 18.

Should Articles 227 and 228 of the Peace Treaty be Carried Out?—These articles refer to the surrender of the ex-Kaiser and certain officers. The letter of Prince Henry of Prussia to H.M. the King offering to take his brother's place, and ex-Crown Prince Rupprecht of Bavaria's offer to be tried by the Bavarian Parliament are praised.

Churchill's Speech on Intervention in Russia.—A translation of the speech, which must from its publication in the *M.W.B.* be pleasing to monarchical Germany.

The Situation at Archangel.—A summary of information from *The Times.*

Step in Rank on Retirement.—Officers whose total service in a rank is within a year of that of the most recently promoted officer above them may claim a step in rank. It appears that promotion in war in the higher ranks was slower than in peace, *e.g.*, to Lieutenant-General from Major-General 3¾ years during the war, 2½ years in peace!

Order of Merit.—Owing to so many unauthorized persons wearing this Order, it has been found necessary to issue a list of recipients. A total of 680 officers received it, viz., Generals (excluding General Staff), 228; General Staff Officers, 72; Regimental Commanders, 145; Other Officers exclusive of flyers, 92; Flying Officers, 75; Naval Officers, 52; Allied Generals, 16.

Rolls of Honour.—Field Artillery Regiment No. 60: 44 officers and over 300 other ranks killed. Field Artillery Regiment No. 2: 28 officers, 53 N.C.O.'s and 256 men killed. Infantry Regiment No. 6: 106 officers killed. Infantry Regiment No. 93: 104 officers and 3,320 other ranks killed.

No. 20 (19 not received).

Joffre's Explanations.—A summary of Marshal Joffre's evidence before the Parliamentary Committee as regards the evacuation of the Briey Basin and his failure to cover the Belgian frontier. That Briey could not be held because it was too close to Metz is accepted as conclusive; but it is insinuated that the French strategists should have appreciated that the German Army could not have left its right flank exposed to Belgian attack.

Regimental Unions.—Thirty-four have now been formed. The notice is tactfully dated 18th June, 1919, "Waterloo Day." Before the war the Germans called the battle "Belle Alliance."

Rolls of Honour.—German South West African troops: 19 Officers and 218 other ranks killed. Infantry Regiment No. 58: 112 officers killed.

No. 21.

The Military-political World Situation.—A survey of what is going on as regards Armies and Navies. "England, the great, mighty wire-

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puller" is dealt with first The writer considers that we can afford the luxury of a small army, but will be involved in a Naval Armaments' Competition with America. America has now a huge Army devised by President Wilson, not to fight the Germans but the Japanese!, etc.

A Review in the Occupied Territory.—An eye-witness's account of a review by General Mangin at Coblence. The Editor regrets that Germans were present as spectators.

Rolls of Honour.—Field Artillery Regiment No. 39: 39 officers and 296 other ranks killed. Infantry Regiment No. 60: 104 officers and 4,130 other ranks killed, 13 officers missing.

No. 23.

General Ludendorff's Life-work.—The commencement of a long review of his book. (Reviewed in *The Times*).

The Reckoning of Private Earnings against Pensions.—A protest against the proposal to take private means and earnings into account in awarding pensions.

Private Property of Members of the Army in Alsace and Lorraine.—It is asserted that this has been seized and sold by the French.

Rolls of Honour.—Infantry Regiment No. 88: 90 officers, 3,377 other ranks. Infantry Regiment No. 113: 93 officers, 2,200 other ranks.

No. 25.

The Fifth Anniversary of the Battle of Tannenberg.—By Major Giehrl who was on the General Staff of a Brigade and the 1st Reserve Corps during the battle. A review of the operations. Like Ludendorff in his memoirs he says "that thousands and thousands of Russians with horses, guns, and colours found death in the Masurian Lakes," is a popular fable (*Märchen*); equally so, that Hindenburg as a General Staff Officer had studied the Lake district, and that Ludendorff was there as a Major. He was first there in 1914.

Ludendorff's Life-work.—Review of his book continued from No. 23.

The Future of the Officers.—On 1st August there were still 20,000 officers. The number must be reduced by the peace conditions to 8,000. A number of posts at present held by retired officers must be vacated to find jobs for ex-active officers.

Rolls of Honour.—Mounted Jäger Regiment No. 6: 21 officers killed, three died at home of disease contracted in the field. Infantry Regiment No. 69: 134 officers and over 3,000 other ranks killed. Field Artillery Regiment No. 25: 38 officers killed, 2 missing; about 500 other ranks killed. Foot Artillery Regiment No. 5: 53 officers, 155 N.C.O.'s and 1,033 men killed.

No. 26.

The Officers' Compensation Law.—The latest news is that officers with 10 years' service who are removed from the Army on reduction, will be pensioned whether wounded or not. War service will count double. Officers below the rank of General will receive in addition a "transition" allowance, and if in proved need "war assistance."

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The " transition " allowance will be paid for 3 years to married officers and 2 years to unmarried. Officers with less than 10 years' service will receive what amounts to half-pay, if under 5 years' service for 1 year, it between 5 and 8 years for 2 years, if between 8 and 10 years for 3 years.

The Fifth Anniversary of the Battle of Tannenberg (continued).—A sketch with the usual assertion that the Russians were three times the strength of the Germans: this forgotten battle is compared to Cannae and we are assured that posterity will recognise its enormous importance.

German War Calendar.—This has not been noticed before. It deals with 1918 and is only remarkable that even in August, 1918, German victories are recorded daily. The following are specimens: They are translated verbatim :—28th—29th August.—The German line on either side of Bapaume and southwards to the Somme is withdrawn according to plan. Heavy defeat of the French between Pont St. Mard and Chavigny. 30th August.—The English continued their attack between Arras—Cambrai and S.E. of Bapaume. The battle ended in the discomfiture of the enemy. 31st August.—The Salient in front of Hazebrouck was abandoned to the enemy; thus Kemmel comes in possession of the English. Between Arras—Cambrai and Peronne the attacks of the enemy collapsed.

Rolls of Honour.—Foot Artillery Regt. No. 14: 75 officers and about 1,500 other ranks killed. Pioneer Battalion No. 18: 31 officers and about 1,000 other ranks killed.

Advertisement.—A General Staff Officer who has entered a printing business begs his former comrades to give him custom.

No. 27.

The Belgian Army before and after the War.—Among other matter it is stated that before the war the Belgian Army suffered from the small number of men with the Colours and short service. Now the Army is popular with all classes and all parties will support it on account of its victories (with the word spitefully in inverted commas).

The Officers' Compensation Law.—Remarks on the speech of a Centre Deputy, who said that 3,500 marks pension for an officer of 17 years' service was too much. Even a workman could not support a family on this sum. (This seems true in Berlin now food for a family of four costs 600 marks a month).

On Subjective Writing.—Reply of Lieut. Hesse, the writer of a book on the war entitled " The Marne Drama," which contains unpleasant truths and deductions therefrom, to General Freytag-Loringhoven's criticisms, who desires only objective truth. He says the truth has been so long concealed that the young of Germany are asking " Is there still truth ? " and only naturally demand what was wrong and what can be improved !

Rolls of Honour.—Foot Artillery Regiment No. 45: 31 officers, 81 N.C.O.'s and 237 men killed. Foot Artillery Regiment No. 43: 28 officers, 53 N.C.O.'s and 178 men killed.

J. E. EDMONDS.

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REVUE MILITAIRE SUISSE.

No. 8.—August, 1919.

THE GERMAN AND FRENCH CAVALRIES IN THE GREAT WAR.

The article on the above subject by Colonel Poudret, begun in the number of the *Revue* for May, 1919 (*vide R.E. Journal* for July, 1919, *et seq.*) is continued in the number under notice. The "exploitation of success" by large cavalry formations is touched upon. The opportunity which the French cavalry had been looking forward to for four years to undertake one of the greatest of tasks that can fall to that arm, namely, the completion of the discomfiture of a defeated enemy, did not come to pass: the acceptance by the German High Command of the armistice terms imposed by the Entente and Associated Powers put an end to the high hopes of thousands of gallant cavalrymen. The part played by the French 2nd Cavalry Corps, and particularly the 6th Cavalry Division, in Flanders during the last three months of active hostilities in 1918, however, provide some indication of the nature of the difficulties which large cavalry formations have to contend with in the case of operations falling under the denomination, "the exploitation of success."

The operations of the 6th Cavalry Division in Flanders and in Belgium during the period, September 18th to November 11th, 1918, are briefly described with the aid of a sketch map, which accompanies the text of the original article. As a result of the six Franco-British offensives of August and September, the Germans had been definitely forced back to the "Hindenburg Line"; and this "Line" was broken, towards the end of the latter month, in the Argonnes and in Artois. The Franco-Belgian attack on the left wing against Sixt von Armin's Army, was launched on September 28th. The French 2nd Cavalry Corps had, since August 19th, been in rest quarters at Beauvais, in rear of the positions from which the attacking troops advanced.

The 6th Cavalry Division moved forward from Chapelle-aux-Pots on September 18th and reached the neighbourhood of Steenwoorde on the 26th *idem.*: it was directed to operate in the direction of Deynze and Ghent, *via* Roulers and Thielt. The division had followed the infantry during the attacks in this region. When the Franco-Belgians had reached the line Staden—Westroosebeke, owing to the turn in affairs, the 6th Cavalry Division, then at Boesinghe, was, on the 30th *idem.*, ordered to push ahead of the infantry at all costs, and to move towards Melle (S. of Ghent) and Brussels. Advancing in two columns, it reached Langemarck and Westroosebeke at 4 p.m. on the same day, leaving the Belgian infantry behind. It was now that difficulties were met with. The Division came up against the Germans holding the ridge which covers Hooglede and Roulers. The enemy was strongly entrenched and amply provided with machine-guns. The French guns were, unfortunately, unable to move forward beyond Langemarck owing to the nature of the ground and, without the assistance of artillery, it was found impossible to make progress. The Division consequently went into bivouacs at Westroosebeke and Oost Nieuw Kerke.

The guns had been got out of the mire by October 1st, and the Cavalry Division was, in consequence, ready to act in the direction of Hooglede

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for the purpose of exploiting any success gained by Massenet's troops. However, the enemy held on to his positions tenaciously, and the cavalry could not be usefully employed in the region. This Cavalry Division was, in consequence, withdrawn and sent into rest quarters at Wylder-Bambecke.

On October 12th, the 6th Cavalry Division was attached to the Flanders Army Group, and on the night of the 13—14th *idem.*, it went into bivouacs N. of the Houlthulst Forest. The Franco-Belgian success at Dixmude on the 13th *idem.* uncovered the German right flank, and the later successes of the infantry again afforded an opportunity for making use of this cavalry force. On the 15th *idem.*, one of its brigades, reinforced by artillery and machine-guns, was therefore sent forward towards Thourout.

The Germans began now to retire slowly eastwards, and were pressed by the Franco-Belgians during their retreat: the cavalry being used to outflank the German rear-guards. By November 10th, the main body of the 6th Cavalry Division had reached the neighbourhood of Cruyshautem, between the Lys and the Scheldt. The infantry crossed the Scheldt between Nederswalm and Audenarde, and drove the Germans back, whereupon the 6th Cavalry Division also began to cross the river, in order to make an attempt to break the enemy's front at Segelsem. One of its brigades had, between 2 and 4 p.m. on the 10th *idem.*, reached the neighbourhood of St. Denis and St. Blaise; another of the brigades was not able to cross the river owing to the insufficiency of bridges. All preparations had been made by the 6th Cavalry Division to take part in the pursuit on the 11th *idem.*, but at 11 a.m. news arrived that the armistice terms had been accepted by the enemy.

A short account is given of the operations in which the Divisional Cavalry took part. It is pointed out that the Divisional Cavalry had a very great variety of duties to perform; it filled gaps in the line at critical moments and also took its share in the trench warfare. Owing to the smaller size of the bodies that had to be handled the Divisional Cavalry was employed with greater success in the pursuit than was the case with the larger cavalry formations. The patrols sent out by the Divisional Cavalry often penetrated deep into the gaps formed by the retreating enemy and constantly harassed the Germans. These patrols on many occasions rendered most valuable services, some of which are recounted in the original article. A copy is published of General Order No. 681, issued by the Commander of the French 121st Infantry Division, in which references occur to the part played by his Divisional Cavalry during the period, August 27th to September 7th, 1918; his thanks and congratulations are conveyed to the cavalry leaders in this Order.—(*To be continued.*)

THE DEFEAT OF THE GERMAN ARMY.

The original article is by Colonel Feyler: he draws attention to the article which appeared in the number of the *Revue* for February last (*vide R.E. Journal*, May, 1919), wherein mention was made of the distinction which certain persons desired to make in the character of the defeat sustained by the German Army on the Western Front; the suggestion being that this army was defeated *morally*, but not *technically*.

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It is stated that recently two important publications have been issued, which form an interesting study on the subject of the above controversy. One of these documents is German and the other French.

The German document is a " White Book," and consequently an official publication. In it are reproduced the correspondence and the telegraphic and telephonic communications which passed between the French G.H.Q. and the Berlin Government during the period August, 1914—November 11th, 1918. The French document is a pamphlet issued by the military authorities entitled : *Pourquoi l'Allemagne a Capitulé le 11 Novembre*, 1918, and gives a brief account of the military operations during the period, July to November, 1918.

The account given of the operations on the Western Front in the publications in question show that surprise remains as important a factor in war to-day as ever it was, in spite of the greatly altered conditions introduced by trench warfare. The results produced by surprise are widened by the events connected with the Cambrai Battle in the autumn of 1917 ; the affair of the Chemin des Dames on May 27th, 1918 ; the breach of the Debropolie on the Balkans Front on September 15th, 1918 ; and the failure of the German Crown Prince's attack in the Champagne on July 15th, 1918.

At the date last mentioned the German forces on the Western Front consisted of 207 divisions, of which 81 were in reserve ; 62 of the latter were " fresh " divisions. The French G.H.Q. had been expecting a new offensive to be launched in July, probably on the 15th ; there were reasons for supposing that the next German move would take place in the Champagne in the region of Rheims : thirty of the German divisions in reserve had been located in rear of the sector Chateau-Thierry—the Argonnes. It is now known that these divisions took part with the normal garrison of this sector in the attack against the French positions.

The attack being foreseen, the German offensive was rapidly brought to a halt after a partial success : a few German troops had succeeded in getting across the Marne between Jaulgonne and Dormans, where they found themselves in a dangerous " pocket."

When the French 10th and 6th Armies delivered their counter-attack from the Forest of Villers-Cotterets on July 18th, the German General Staff should have appreciated that it was too late for their plan to succeed. At this date, there were 40 German divisions in the bend of the river, and there was only one railway line to supply them ; a line which, in the neighbourhood of Soissons, passed within less than nine miles of the French front. Foreseeing the possibility of a French attack from the direction of the Forest of Villers-Cotterets, the Germans had placed eight divisions in their second line "in the pocket " formed in this part of the Western Front during the mid-July offensive. The provisions made by the Germans in this region proved insufficient : the counter-attack by the French 10th Army took them by surprise and they were at a single stroke driven back beyond the Soissons—Chateau-Thierry road, which fell into French hands. At the same time, the French 5th Army advanced on the east of the " pocket." Three French Armies, reinforced by the Americans and an Italian Corps, now made a

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converging attack on the Germans holding the " pocket," and the latter were obliged to fall back, slowly it is true, but suffering heavy casualties in order to save their supplies. The Germans had planned a second offensive to take place, about the same time, in the region of Lille against the British lines, but this they were obliged to abandon.

Having thus secured the initiative, the French G.H.Q. next planned operations with the object of reducing the " pocket " N. of Montdidier. The task of doing so was allotted to the British 4th Army and the French 1st Army ; these armies were set in motion on August 8th on the front Albert—Moreiul along the Amiens—Roye Road : the Germans began to withdraw on the 15th *idem.*

The German White Book mentioned earlier in this article begins with the description of the events taking place on the Western Front on August 14th. On this date, a conference took place at Hindenburg's Headquarters, then at Spa. The German Commander-in-Chief was at this time of opinion that his army could still hold out. On the other hand, Burian, the Austro-Hungarian Foreign Minister, was at this time proposing that an attempt should be made to secure a peace by compromise : he had suggested that a meeting should be arranged in some neutral State between representatives of the belligerent Powers.

Marshal Foch's message of August 12th to the armies operating under his supreme command is recalled ; he therein stated : " One hundred and twenty German Divisions have been heavily engaged against us since July 15th ; we have to meet a situation which will not recur and which requires us to put forth all our strength and power." It was in connection with the Battle in Picardy, which began on August 8th, and consisted of four distinct phases, that Foch's troops were called upon to make their great effort finally to wrest the victory of the campaign.

The result of the operations that followed is summed up in the Summary prepared by the French 2nd Bureau on September 26th :—Of the 207 divisions which the Germans had in July on the Western Front, 163 had taken part in the fighting—75 of the latter had engaged twice or even three times. The German General Staff had been able to reconstitute 68 divisions as a reserve, but of these only 21 were " fresh." Although the German front had been reduced by 125 miles, they had still to employ the same number of divisions in their first line positions as on July 15th, owing to the strength of the units and their *morale* having been so reduced—15 divisions had been entirely wiped out, and in 50 of the remaining divisions the battalions were reduced to three companies apiece.

The seriousness of the situation, as can be seen by the account given in the German White Book, was at last brought home to the authorities in Berlin, and this it was that led to the desire on Hertling's part to re-open peace negotiations with President Wilson : the Germans were now prepared to renounce many of their pretensions.

At the same time, Marshal Foch fully realized that the German Armies were in a sufficiently tired out and disorganized state to justify one last great effort to break them up finally. Three great converging attacks were, in consequence, planned and resulted in the Battles of the Champagne and the Meuse, of Cambrésis and of Flanders,

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It is recorded that Hintze arrived at the German Headquarters on September 29th ; and the order was given on that day to hoist the white flag. A telegram was sent to Berlin at 9.40 p.m. wherein directions were sent to the Wilhelmstrasse to break the news confidentially to Vienna and Constantinople that Wilhelm II. intended to approach President Wilson to seek peace on the basis of the latter's 14 points.

The telegrams sent at this period from the German Headquarters to Berlin indicate that the German High Command had begun to lose confidence in its troops and on October 1st Ludendorff is found urging that the peace offer must be sent off immediately to Washington, as the troops could not be trusted to hold out for longer than another 48 hours. However, Prince Max of Baden, who had become Imperial Chancellor, was not to be hurried : he enquired whether the military authorities appreciated the consequences that might follow on a demand for peace owing to the weakness of the German military situation. However, Hindenburg and his Chief-of-Staff were fully aware of the extreme dangers that the German Army now ran, and, whatever the consequences might be, they were insistent in their demands for peace.

The statements compiled from the intelligence collected at Marshal Foch's G.H.Q. show that, between September 26th and October 20th, out of 191 German Divisions remaining on the Western Front 139 had been engaged in the fighting. It had been ascertained, as early as October 11th, that 44 German Divisions in the line had suffered so heavily as to be unfit to take further part in any serious fighting. Therefore, from a practical point of view, the German reserves were used up.

On the other hand, Marshal Foch had a large number of " fresh " troops in hand, and was able to plan operations for the invasion of Germany.

President Wilson had, on October 5th, replied to the Central Empires' messages and informed them that he did not feel justified in intervening in the military situation. Telegraphic correspondence ensued, but Berlin got no satisfaction. Finally, on October 27th, Germany realised the complete hopelessness of her position and asked to be informed the terms on which an Armistice could be concluded. The terms were made known to the *parlementaires* sent to Marshal Foch from Hindenburg's Headquarters. Berlin considered the terms extremely severe, and whilst instructing the *parlementaires* to endeavour to obtain some relaxation, informed them that if they were unsuccessful in obtaining a modification of the terms, they must agree to them " in any case."

The reason for this decision is apparent when the state of the German Army is realized. By November 10th, the German divisions on the Western Front had been reduced from 207 to 187 ; of the latter only 17 were in reserve, two alone being " fresh." At the date of the offensive in March, 1918, the strength of a German infantry company was about 120 men, by July 15th this strength had been reduced to between 70 and 90 men, and by the beginning of November to 50 men.

The loss in artillery had also been very great. On July 15th the Germans had on the Western Front 3,100 field batteries—say 12,500 guns—and 2,150 heavy batteries—say 7,860 guns of all calibres—comprising a total of some 20,360 guns. At the beginning of November

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there remained of these but 2,600 field batteries and 1,605 heavy batteries: the loss in guns totalled 6,860 pieces of all calibres.

Colonel Feyler, in conclusion, states that although no soldier will refuse a word of praise to the German Army for the stubbornness with which it fought, on the other hand, no one can any longer assert that it was not completely defeated.

OFFICIAL DINNERS.

The original article contains a criticism of a practice which has come into existence during the period of the "War Mobilization" of holding "official dinners." It would appear that the C.O.'s of certain units have been in the habit of issuing *orders* to their subordinates to dine together: the intention has been to promote good fellowship, but the result appears to have been far otherwise. Complaint is made that these entertainments impose a heavy financial burden on the junior officers, a burden which they are not in a position to bear.

NOTES AND NEWS.

Switzerland.—Two matters are occupying a considerable amount of attention in military and civilian circles in Switzerland: the proposed entry of Switzerland into the League of Nations and that of the Vorarlberg into the Helvetian Confederation. The first question was referred to the Commission on National Defence, which has reported favourably on the proposal; the German-Swiss officers are, however, opposed to the scheme on strategic grounds.

The Vorarlberg question is still under discussion in the Press, a certain section of which seems to be extremely hostile to the incorporation of this region into Switzerland. The chief reason for this hostility arises from a desire not to increase the proportion of the German element in the Swiss nation and the number of Roman Catholics in the Republic. It is pointed out that Switzerland has in the past always been ready to accept within its fold those who have asked to be admitted to membership of the Confederation.

The *Revue* is in favour of the Vorarlberg being admitted to membership, as the 23rd Canton of the Confederation, provided suitable measures can be made for dealing with the war debt of this region incurred by Austria.

The death is announced of Colonel Paul Etier, of the Swiss Engineers. He was better known in Switzerland as a politician than as a soldier, being President of the Vandois Government at the time of his decease.

W. A. J. O'MEARA.

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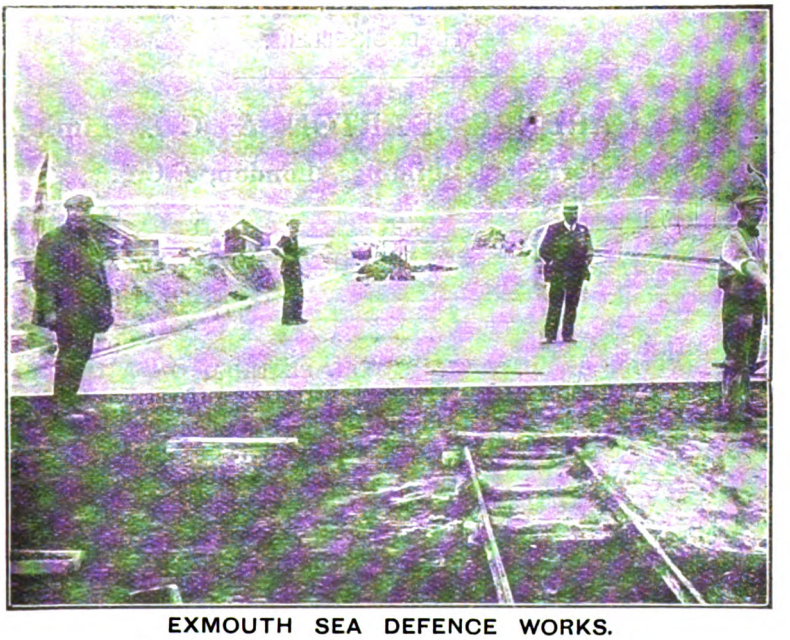

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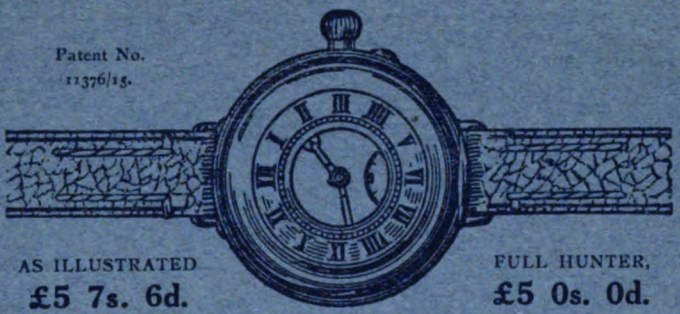

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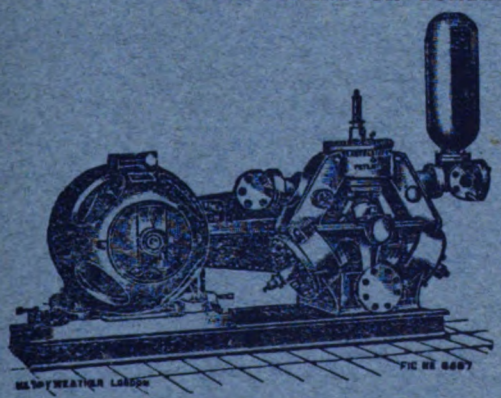

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THE ROYAL ENGINEERS JOURNAL.

Vol. XXX. No. 6. DECEMBER, 1919.

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MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the R.E. Institute Council in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. From the beginning of 1920 it has been decided that the Prize shall be confined to Officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions :—

(*a*). Descriptions of works actually carried out in peace or war.
(*b*). Inventions.
(*c*). Design (excluding works of defence).
(*d*). Labour organization on work.
(*e*). Scientific investigations generally.
(*f*). Accounts of exploration work and surveys.

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A NEW METHOD OF SOLVING "VISIBILITY" PROBLEMS.

By MAJOR C. F. ATKINSON, *late East Surrey Regt.*

QUESTIONS of visibility and cover frequently arise in map-reading. These can of course always be solved, so far as the fulness of the contouring and spot-levels permits, by drawing a section of the ground along the line considered. But this method is laborious, and the various methods that have been proposed as substitutes are all open to objection for one reason or another, except in the cases that can be settled by a mere inspection of the map.

The following method, which is believed to be a new one, is simple, rapid and accurate, and needs only a ruler with two parallel edges, one of these having a scale of (any) equal parts.

The problem may arise in one of three forms, (1) to ascertain whether any intervening obstacle interrupts the line of sight between the point of view and the object; (2) to find the nearest point of view from which the object is visible over the top of the obstacle; (3) to find the nearest point beyond the obstacle at which the ground becomes visible from the point of view.

In each case, two points are given, as regards position and height, and the positions or heights, or both, of other points are to be examined with reference to these.

Method.—Parallel to the line of points on the map, draw any other line and graduate it in units of height *backwards* (that is, with the scale zero to the right if the lowest point on the map line is to the left, and *vice versa*). In practice, the actual zero is not required, and a partial scale numbered according to the heights that enter into the particular problem suffices.

Draw a line from each of the two given points on the map-line to its appropriate graduation on the scale-line. These lines intersect at a point A and it is by means of this point that the problem is solved, in whichever form it is presented.

Case (1).—*To ascertain whether any intervening point V′ interrupts the line of sight from a point of view V to an object V″.*—Find point

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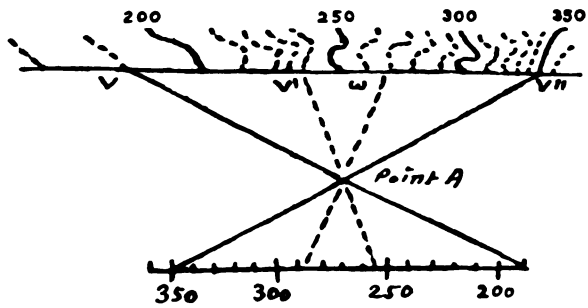
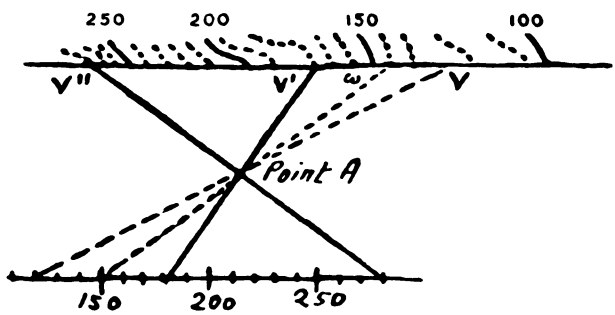
A by lines from V and V″ to the scale, and test the possible obstacles in succession thus :—from the suspected point V′ draw through A a line to meet the scale. This does so at a graduation corresponding to the *critical* height for an obstacle of that position, *i.e.*, the height at which it is neither above nor below the line of sight V—V″. Comparison of this height with the real height shown on the map at once indicates whether the line of sight is interrupted.



Point V′ has a critical height of 253 ft. and a real height of 240 ft.
Point W has a critical height of 289 ft. and a real height of 270 ft.
Neither, therefore, intercepts the line of sight V—V″.

Case (2).—*To find the nearest point of view V from which the object V″ is visible over the obstacle V′.*—Find point A from V′ and V″ and (working outwards from V′ so as not to miss any significent feature) test likely points on the map-line by finding their critical heights through point A, as in case (1), and comparing these with the respective real heights.



At trial point W, critical height 150 ft. and the real height 140 ft., V″ is invisible.

At the second trial point the critical height is 120 ft. and the real height about 124 ft., so this is taken as V.

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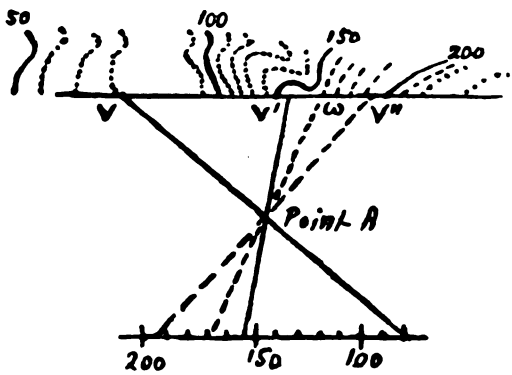
Case (3).—*To find the nearest point V″ at which the ground is visible from the point of view V over the obstacle V′.*—Find point A from V and V′, and proceed as in case (2).



The trial point W, critical height 170 ft., real height 160ft., is invisible from V.
Point V″, with a critical height of about 193 ft. and a real height of 196ft. is selected.

NOTES.

The accuracy of work depends on a sharp intersection at A, and on nothing else.

To avoid working in negative angles, always assume the observer to be at the bottom, looking uphill. Thus, in finding the nearest point in low ground visible to an observer above the obstacle, proceed as for case (2).

After a little practice, only the scale line and the intersection defining point A need actually be drawn, the rest of the work being done with the edge of the ruler. The line of points on the map must of course be definite.

In cases (2) and (3), if the ground *beyond* the selected V or V″ has to be tested, this point is to be treated as a new potential obstacle and a new point A found. Of course if the selected V or V″ were *exactly* of the critical height this would not be necessary. But in practice a few feet would be allowed as a safety margin in selecting V or V″, and this involves the finding of a new A, which however, is very easily and quickly done, either with the old scale and one of the old lines, or with a new scale. This process can be repeated indefinitely along the line of sight in question. Similarly, in case (1), a piece of ground which has been found to intercept the view from V to V″ may itself be available as a point of view and may be tested by a new point A.

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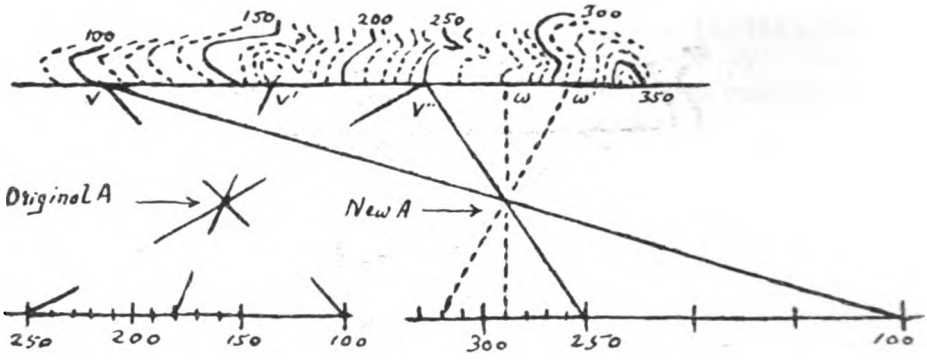

V" having been determined, the ground beyond is tested by a new point A (found from V and V").

Trial point W is invisible from V (critical height 290 ft., real height 270 ft.). But at point W' the critical height and the real height coincide, and the ground becomes visible.

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THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914—1919.

BRIDGING.
(Continued).

CHAPTER III.

BRIDGING OPERATIONS—AUGUST TO NOVEMBER, 1918.

(*Reference* MAP *following* PLATE XXIV., *page* 216, R.E.J., *November*).

Introduction.—Army Organisation.—The Ancre River.—Somme River and Canal and Tributaries.—Canal-du-Nord.

1. INTRODUCTION.

Before proceeding to describe the operations during the final advance, it will be as well to summarise briefly the work that had already been done.

At the beginning of the final advance of the British Army the War had already lasted four years, during which time about 180 Standard Span Heavy Bridges had been erected. Of these the only ones built under conditions at all similar to those about to be experienced during the advance, were the Fourth Army Bridges across the Somme in 1917, and to a lesser extent in April—May, 1918.

Steady training had been in progress at the Bridging School, and most of the officers and men of the R.E. Field Units had got a certain amount of knowledge of the nature and handling of the type spans.

Only a few units as such had had either training or practical experience in the work, and the heavy losses of *personnel* during March and April had greatly increased the numbers of untrained men.

Large quantities of material were on order from England, but deliveries were slow, and congestion in all factories made it impossible to accelerate the programme, whilst stocks in France had been much reduced by various causes already explained.

During the bare three months that elapsed between the beginning of the Fourth Army advance and the conclusion of the Armistice, approximately 330 Stock Span or Rolled Steel Joist Bridges were erected, or nearly double the number that had been used during the whole of the preceding four years. A complete account of all the bridging work done during these three months would fill many volumes. All that can be attempted here is to describe generally

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the work done in crossing the main rivers and canals, with a few of the more important and interesting operations in detail. A short account of the hasty bridging by Divisional Troops will be found in the next chapter.

2. ARMY ORGANISATION.

Profiting by experience already gained, each army made the most careful preliminary arrangements both for study and reconnaissances of river and canal crossings with which they were faced, and also for the organisation of the special staff, transport, and depôts, that would be required.

The systems followed did not vary much, and in almost every case the most experienced officer available was placed in charge of the Army or Corps Bridging Depôt, the actual superintendence of the work of erection being entrusted to the O.C. of the Unit engaged.

A good deal of trouble was found in providing sufficient skilled labour at the Bridging Depôts, and nearly every variety of R.E. Unit was employed at one time or another. Views taken in an Army Depôt are shown in *Photographs* XXV., XXVI. and XXVII.

The work became increasingly technical and important as the advance went on, and salved material had to be taken over, repaired and re-used. Most of the armies also had to undertake a certain amount of work in dismantling heavy bridges in back areas, which were no longer of use where they were, but were required for re-erection further forward.

The supply of stock spans to keep pace with the advance was a matter of grave concern, and units were urged wherever possible to use stock rolled steel joist spans, of which a large number were always available. These had the additional advantage of being very simple in erection, and were particularly suitable for use by Divisional Field Companies, which had had little opportunity of training in the erection of Girder Bridges.

The increasingly important *rôle* played by Tanks in the advance, and by Heavy Artillery, made it necessary for Divisional Troops to erect bridges to carry the heaviest loads immediately a passage had been secured by the Infantry, and for this purpose the rolled steel joist spans were invaluable. By using them in conjunction with standard piers, bridges of any ordinary length were built under the worst conditions in a few hours; the use of winches and derricks was avoided, and in many cases it was found possible to build such bridges during the night at a comparatively short distance from the enemy; a further advantage was that damage by shell fire was easily repaired. On at least one occasion Tanks were even bridged over a water obstacle with the first Infantry attacking wave.

Great use was again made of the Inglis Rectangular Bridge, of which, however, only a limited amount was available.

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3. The Ancre River.

In the first stages of the advance the Third and Fourth Armies were both faced with the considerable obstacle of the Ancre River and its flooded valley.

It was expected that much heavy bridging work would be necessary, but so rapidly did our troops advance that only temporary bridges were required in any quantity, and heavy bridges were constructed only on the main routes.

The Fourth Army work was carried out by the 283rd A.T.Company, R.E., and consisted entirely of R.S.J. spans, with the exception of one 60-ft. bridge across the Railway on the Amiens-Albert Road.

The 147th and 280th Army Troops Companies, and the 2nd Siege Company, R.A.R.E. did the Third Army work, which consisted of three 60-ft., and several R.S.J. spans.

The main causeway across the Ancre valley at Aveluy had been almost entirely destroyed by our own shell fire and by the Germans in their retreat, and this had to be entirely rebuilt. A 60-ft. span, and two 20-ft. R.S.J. spans were erected in the causeway itself in order to release flood water from the upper areas.

4. Somme River and Canal, and Tributaries.

The first crossings were all constructed by the Australian Corps.

A noticeable piece of work was done at Chipilly by the 3rd Australian Pioneers. Two High Level Steel Lattice Bridges existed before August 8th, one a French civilian and the other a French military bridge, the latter being of a longer span than the former. Both bridges were blown at one end by the enemy.

The length of the military bridge left undamaged was found to be sufficiently long to span the civilian bridge abutments. The bridge was picked up, a few new members made, and was placed in its new position in four days, producing a first-class single way bridge for all loads except Tanks.

An 85-ft. length of Inglis Rectangular Bridge was erected at Vaire on the 11th of August.

This was dismantled and re-erected at Bray on the 30th August. It was later replaced here by R.S.J. spans on piles, and was again used in the crossing of the Selle River in October.

The crossings in Peronne were reconnoitred on the 2nd September, and it was found that of the old British bridges only one 60 ft. Class A span remained intact. Temporary R.S.J. bridges for Mechanical Transport were started on the 4th, and completed on the 5th.

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Semi-permanent bridges were commenced on the 10th as follows:

At Bristol Bridge site, shortened 60-ft. Class A span opened to all traffic 14th September, 1918, duplicated by a R.S.J. bridge alongside.

At Faubourg-de-Paris—Two R.S.J. bridges alongside each other, 30-ft. span, completed 16th September, 1918.

On Peronne-Flamicourt Road—Tank Bridge made of German Rolled Steel Joists, completed 7th September, 1918, and a salved shortened 60-ft. Class A bridge completed by 26th September, 1918.

All this work was carried out by the 574th A.T. Company, R.E.

The most important crossing of the Somme was at Brie. Reconnaissance of the sites was made on the 5th September.

The Germans had destroyed all the bridges, and the following new spans were erected over the five gaps:—

(*a*). 30-ft. Reinforced.
(*b*). 21-ft. 6-in. Reinforced.
(*c*). 60-ft. Mark II.
(*d*). 21-ft. 6-in. Reinforced.
(*e*). 60-ft. Mark II

The 60-ft. bridges were erected as deck spans to allow Tanks to cross with sponsons out. This meant a considerable amount of extra work, as approach ramps had to be built up at each end.

The first spans were delivered at the sites on the 6th, and all five bridges were completed and opened for all traffic on the 9th.

It is interesting to compare the time taken with that for the same crossings at the beginning of 1917.

The second series, consisting of three 60-ft. spans, and two made-up rolled steel joist bridges, were delivered at the site on the 14th, and completed alongside the first series on the 18th. This work was carried out by the 216th and 574th A.T. Companies.

The rapidity and smoothness of the whole work was striking proof of the value of the training these Companies had received.

Another series of heavy bridges was erected at St. Christ, by the 4th Siege Company, R.A.R.E.

5. CANAL DU NORD.

The Canal du Nord, which connects the Sensée Canal with the Somme Canal, was at the outbreak of war in process of construction, and its state of completion varied considerably on the front of the First and Third Armies. In the southern portion a considerable

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length is carried through a tunnel, and so presented no obstacle to our advance, but the very deep rough cuttings on other portions made a formidable gap, and the steepness of the banks made approaches to low level bridges difficult. A very large number of temporary crossings were made, but the speed of our advance beyond the canal made it unnecessary to build many permanent bridges.

On the Third Army front the most important was on the Hermies-Havrincourt road, where a 180-ft. span Hopkins Bridge was erected, this being the longest single span bridge put up in the advance. This work seems of sufficient interest to be described in more detail.

A reconnaissance of the crossing was made on the 22nd of September by the O.C. New Zealand Tunnelling Company, and the G.H.Q. Bridging Officer. The approach road to the original brick bridge runs along a ridge, and across the canal cutting, which is here dry, 100 ft. above bed level. In order to screen the new bridge from enemy observation a site was selected about 100 yards further south. At this point the gap was 180 ft. wide, and 85 ft. deep.

The tactical situation did not allow any work to be commenced until the 27th September, on which day, in spite of considerable shelling, material began to be delivered at the site; the marking out of the work was completed on the same day. Erection was commenced on the morning of the 28th September, and after twelve hours' work, 24 bays of the lower chords, 2 bays of the top chords, and 15 diagonals had been assembled. Excavations for the abutments, anchorages, and launching gear were also completed.

During the 29th seven bays of the lower chords, 16 bays of the top chords, 48 diagonals, five top cross joists, two bays of wind bracing, and two bottom chord stiffening joists were assembled. A delay of several hours was caused owing to the breakdown of material lorries. All winches were bedded and fixed, and derrick beds were laid and secured.

The assembling of the bridge and rigging of the launching tackle was continued throughout the 30th, and was completed by noon on the 1st October.

The standard method of erection for this type of bridge is to assemble the bridge, less flooring, on one side of the gap, and to haul it into position by means of winches and derricks on the opposite side.

In order to reduce the load on the tackle a counter-balance arm and weight may be used—in this case the girders were extended to a total length of 240 ft., and a 20-ton weight was placed on the end of the extension. The bridge was lowered by means of jacks on to rollers, and was launched forward one bay before dark on the 1st.

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On the 2nd October launching was continued until there was an overhang of 112 ft. beyond the centre rollers, the span not then bearing on the abutment rollers.

At this point the lower chord members bearing on the centre rollers showed signs of failure due to longitudinal buckling of the webs of the channel girders. One channel member failed completely and commenced to slip off the rollers. The span was jacked up, and the damaged channel member was replaced by one taken from the end section of the counter-balance extension.

On examination it was found that though the distance between the channel girders of the lower chords was exactly 2 ft., the distance between the rollers of the centre pair where failure had occurred was 2ft. $0\frac{3}{8}$ in. In the case of the other rollers this distance was 2ft. $0\frac{1}{4}$ in.

The channel girders being placed back to back the webs were partly off the rollers when the chords were truly central, and the slightest deviation of the chord from the centre caused one web to gain a better bearing and the other to slide off the roller entirely.

As the rollers could not be altered, a second pair was fixed as close as possible to the abutment pair, and hydraulic jacks were placed under them in order to allow adjustments to be made to distribute the load equally. The fixing of the new rollers and the repair of the lower chord caused a delay of about seven hours before launching could be resumed.

By 5 p.m. on the 2nd October, the head of the bridge was 110 ft. beyond the abutment bearing. On the 3rd October launching was continued successfully until the head of the bridge was within 8 ft. of the east abutment, when one of the winches jammed, and a crib pier had to be erected under the end of the span, which was then jacked up so as to take the weight off the tackle. Shortly afterwards the second winch jammed, and the span had again to be jacked up. Launching was completed, and the span finally bedded at 4 p.m., and the dismantling of derricks and. counter-weight extension were at once commenced.

On the 4th of October tarpaulins were slung under the bridge to give the men confidence while fixing the deck beams, and to protect traffic passing along the bed of the canal from any material that might be dropped accidentally.

By the evening all transoms, deck beams and decking had been placed in position, but not finally fixed.

Owing to the length of the span it was thought necessary to provide extra horizontal bracing; for this purpose wire ropes were fixed 60 ft. from either end on both sides of the bridge, and tied back to anchorages on the bank 60 ft. from the centre line. This was all completed by 5.30 p.m. and the bridge was open to traffic at daybreak on the 6th October. *Photograph* XXVIII. shows the tem-

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porary diagonal wire rope bracing. *Photograph* XXIX. shows the total length of the bridge with tail. *Photograph* XXX. shows the bridge as it appeared from the bed of the canal. *Photograph* XXXI. shows the attachment of the tackle to the heads of derricks.

Measurement of the rollers used in launching showed that those supporting the heavier loads had been reduced in diameter from ¼ in. to ⅛ in. at the ends where the webs of the lower chord channels were supported.

A light wire rope transporter, which had been erected near the site, was used throughout the work, and was found most valuable as a means of communication across the gap.

During launching, the head of the span dipped gradually to a maximum of 11 ft. below the level of the abutments. The maximum dip occurred when the head was 20 ft. from the far abutment. The average rate of launching was 16 in. per minute while the span was actually in motion. The launching weight was approximately 120 tons.

The camber of the bridge as erected was 9 in. at the centre—on completion it was 7⅝ in., and after one day's lorry traffic this was reduced to 6½ in. The troops engaged in the work consisted of:—

New Zealand Tunnelling Company ...	11 Officers.	257 O.R's.
565th A.T. Company	3 ,,	48 ,,
577th A.T. Company		5 ,,
Total	14 ,,	310 ,,

Party in Charge of Dump and Directing Transport:—

New Zealand Tunnelling Company ...	2 Officers.	50 O.R's.

The most important of the other Third Army bridges over the Canal du Nord was a three 60-ft. Span Bridge on standard trestles at Etricourt. This work was done by the 147th A.T. Company, assisted by detachments from the 4th Siege Company, R.M.R.E., and the 183rd and 175th Tunnelling Companies.

The steel-work was erected as a continuous bridge on the west bank of the canal, and was hauled across the gap, on rollers.

The time taken upon the erection of the steel-work and completion of spans for traffic was six days, included in which was a delay of a full day owing to the non-arrival of sufficient rollers. 3,475 man hours were employed on this work as compared with 5,760 man hours, which is three times the book estimate for erection of a single 60-ft. span. The officer in charge was confident that but for the hitch in the supply of rollers, the work could have been completed in four days.

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The First Army bridges were mostly of rolled steel joist types on trestles or cribs. Two Long Span Inglis Bridges were also used.

In one case an effort was made to launch a 108-ft. Inglis span at night, but this was found impossible and had to be left till daybreak, when the work was completed in 4½ hours. *Photographs* XXXII., XXXIII., XXXIV. and XXXV. show typical examples of work done.

(*To be continued.*)

[Previous articles under the heading of "The Work of the Royal Engineers during the European War, 1914–19" appeared in the *R.E. Journals* of September, 1919 (Introduction p. 105; Anti-Aircraft Searchlights, France, p. 106; Postal Section—Army Postal Services, p. 114), October (Bridging, Chapter I., p. 162) and November (Bridging, Chapter II., p. 209). Copies of these Journals may be obtained through the usual channels.]

ERRATA CHAPTER II. (R.E.J., NOVEMBER, 1919).

Page 212, line 23, *for* "apan" *read* "span."

Page 212, line 23, *for* "tube" *read* "cube."

Page 213, line 37, *for* "to be" *read* "been."

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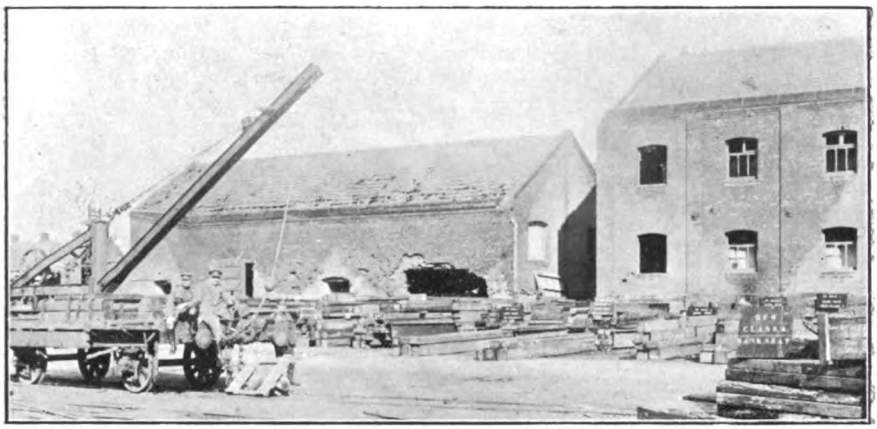
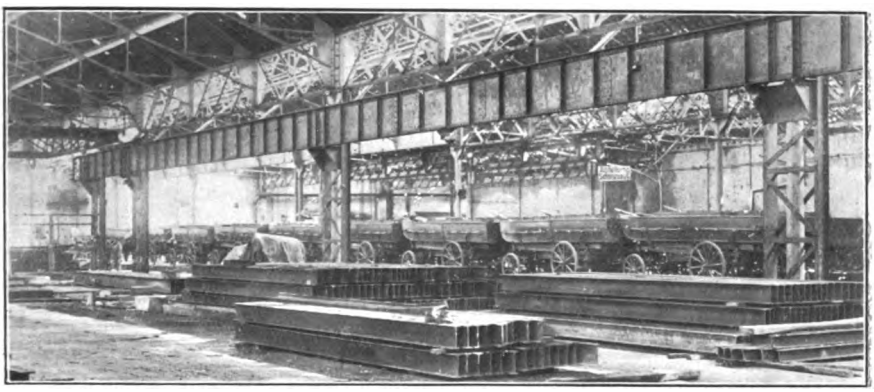
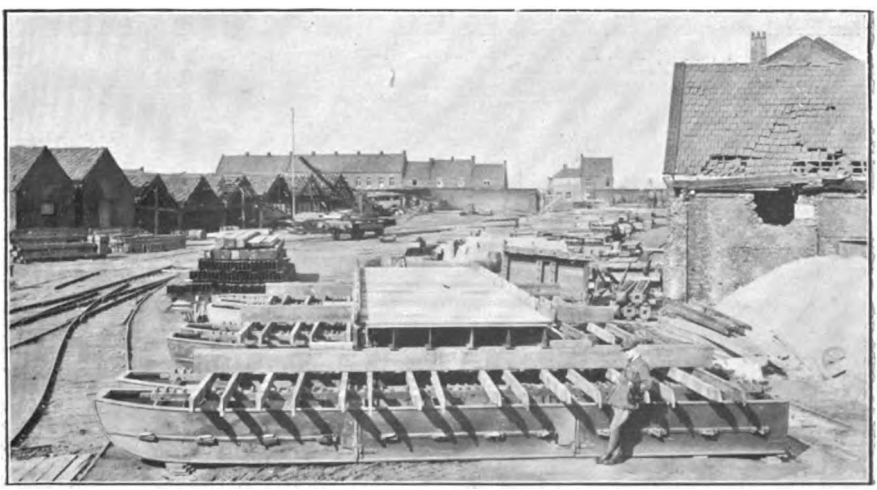


Photograph XXV.



Photograph XXVI.



Photograph XXVII.—Views taken in an Army Bridging Depot.

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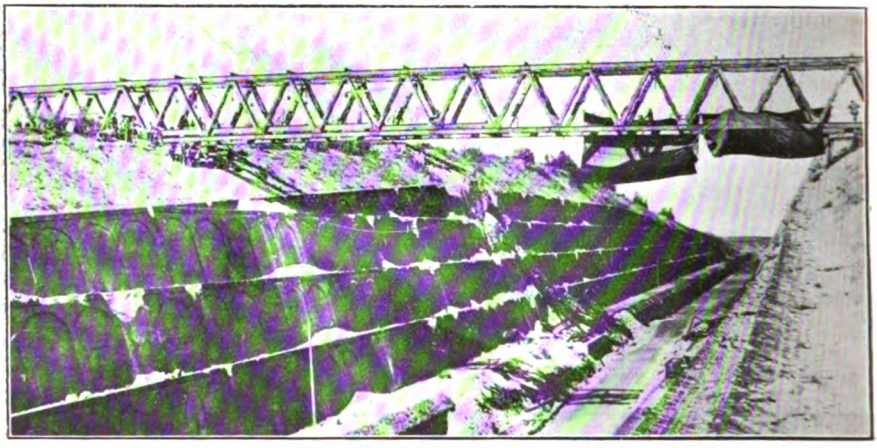
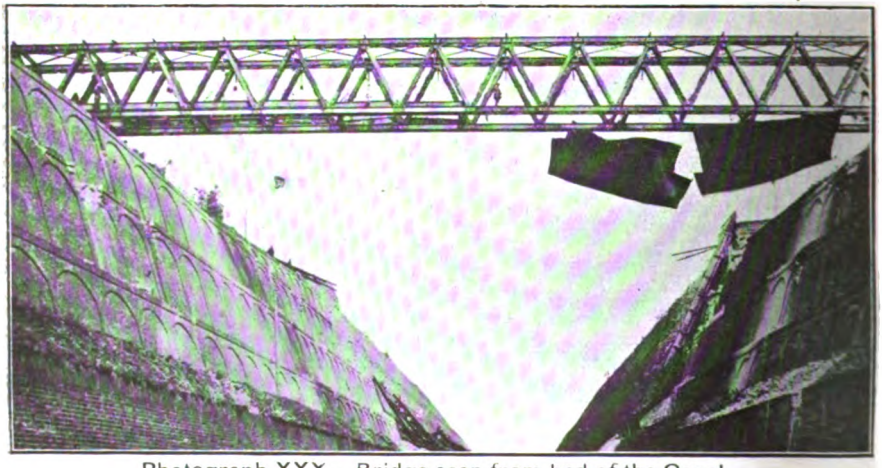
Photograph XXVIII.—Temporary Diagonal Wire-rope Bracing.



Photograph XXIX.—Total length of the Bridge with tail.



Photograph XXX.—Bridge seen from bed of the Canal.

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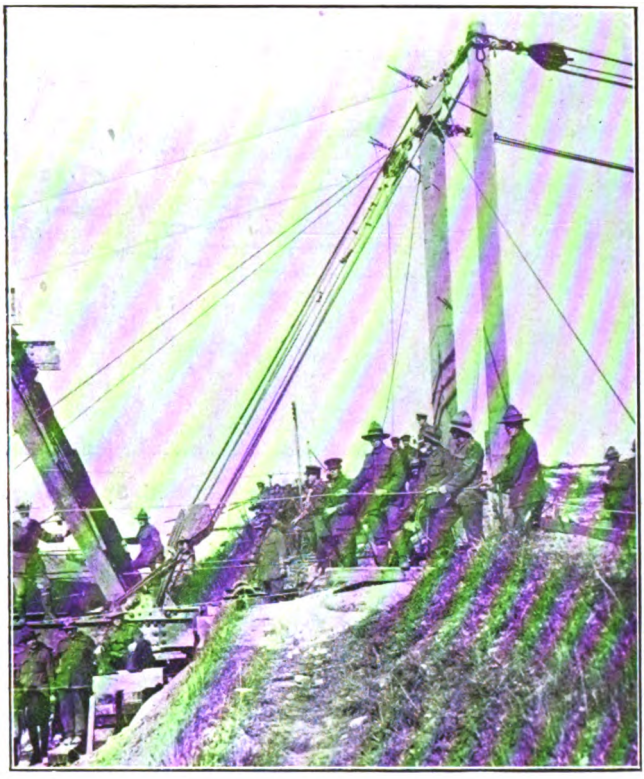
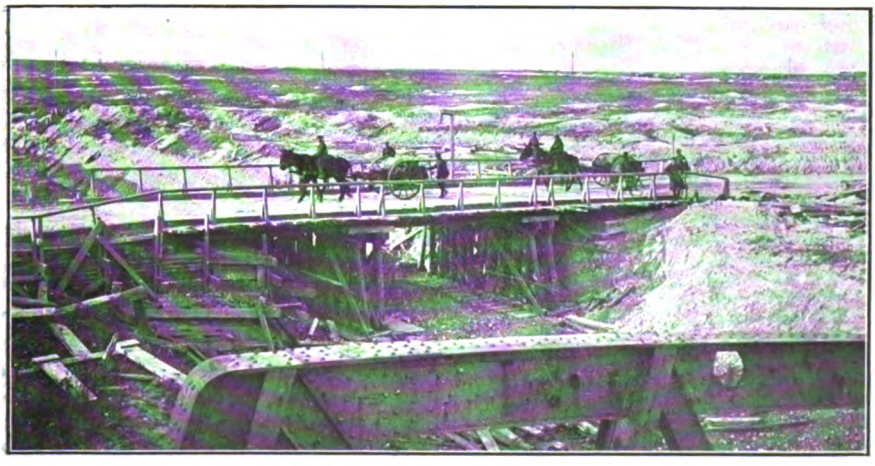


Photograph XXXI.—Havrincourt, Canal du Nord: Attachment of the tackle to the heads of derricks.

Hopkins 120-ft. Type Bridge, Clear Span 180 ft.
Work started 28th September, 1918.
Photo taken 3rd October, 1918.
Bridge opened for Traffic 6th October, 1918.



Photograph XXXII.—Canal du Nord: R.S.J. Spans for all loads.

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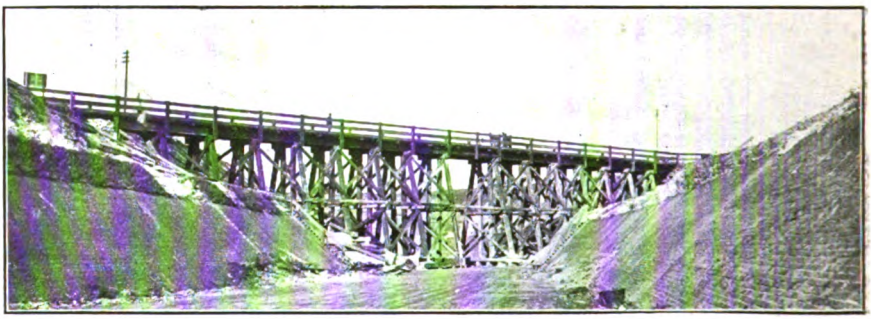
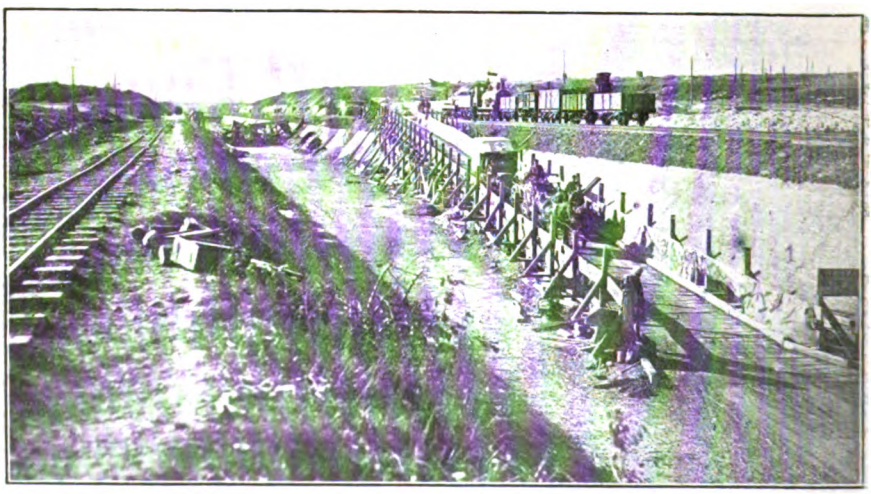
Photograph XXXIII.—Canal du Nord. Typical R.S.J. Span across Lock.



Photograph XXXIV.—Canal du Nord: Timber Railway Bridge.



Photograph XXXV.—Canal du Nord: Typical Timber Ramp.

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NOTES ON STATIONARY STORAGE BATTERIES.

By Captain H. DE C. TOOGOOD, A.M.I.E.E , R.E.

THE desirability of some notes to emphasize, and perhaps to amplify, the principles laid down in text books for the Engineer entrusted with the operation and care of stationary storage batteries, which are apt to be sometimes somewhat generally insufficiently regarded, came to my notice during the four years I was an Assistant Inspector of R.E. Stores at Woolwich from 1914—1918. These notes are not intended as an exposition of all the principles connected with the subject, for which the reader is referred to any standard text book.

Design.—The usual service type consists of a Planté positive and a box negative, often having wood separators. The advantages claimed for these over other types, *e.g.*, glass amongst others, is that the battery has a longer life at full capacity owing to the porosity of the plates being more permanently maintained. Another practical value of the wood separator is the prevention of internal short circuits.

The positive plate must be prevented from a continuous close contact with the wood separator to obviate quick rotting of the wood separator. For this reason the separator is a thin diaphragm supported by circular or grooved dowels. The negative plate is always designed to have excess capacity over the positive plate, and this condition must be maintained in the cells by proper operation and maintenance.

The positive plates are worked at a higher current density than the negative plates. It will be noted that the negative plates in a cell exceed the positive plates in number.

The size of the battery to be installed is in the service usually decided upon for the Engineer and it is his duty to maintain the battery up to its maximum capacity during its life.

Capacity.—It does not seem to be sufficiently realized that an accumulator is analogous to an athlete in this respect. The capacity of the battery may be compared to the capacity of an athlete. It is just as absurd to take a long distance champion and use him for sprinting races for which he is by nature unsuited, as it is to use a 1,000 A.H. battery for the purposes for which one of 200 A.H. would

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suffice. Apart from being uneconomical, the battery would fail as assuredly as the athlete if, after only doing 100 yard sprints, he were without training suddenly called upon to run in a two-mile race.

Necessity for Working the Battery.—Exercise and work then, and *of the right sort*, intelligently mapped out, is an essential condition for maintaining a battery in a healthy state, so that on emergency it will do its performance without "letting you down."

Discharge.—In plain language this means arranging your production of power so that the battery is discharged at a suitable rate and sufficiently exhausted, sufficiently often per week, say at least up to 60 to 70 per cent of its capacity, and that further, say once a week, the battery is run down to the lower limits given on the maker's card of instructions, in conjunction with which the customary voltage and specific gravity readings are taken and intelligently interpreted with a view to discovering and diagnosing weak cells and other signs of disease or irregularity not previously observed, correct treatment for which must be put in hand without delay.

It should be noted that the capacity of the battery varies with the rate of discharge according to the well-known Planté type curve. Thus, assuming the capacity of a battery, at 60° F., at the 5-hour rate of discharge, to be 100 A.H., the capacity at the 10-hour rate is 120 A.H., and at the 1-hour rate is only 60 A.H., *i.e.*, half as much at the same temperature. Thus in working the battery due regard must be paid to the rate of discharge. The capacity of the battery increases with rise, and decreases with fall of temperature at the rate of about 1 per cent. for each 2° F. above and below 60° F.

The final permissible volts per cell on discharge also vary with the rate of discharge. At a 10-hour rate of discharge the R.E. specification permits a voltage drop down to 1·85 v. per cell. At a higher discharge rate it is permissible to run the battery down so that the voltage per cell is lower, *e.g.*, at the 1-hour rate of discharge this figure may be as low as about 1·7 v. The maker's chart should be followed however, as this figure varies with the make.

In measuring the voltage it is desirable that the discharge rate be not less than the 10-hour rate at the time of taking the reading. Readings taken on open circuit or with small currents flowing are valueless.

The reason for the reduced capacity at higher discharge rates lies in the fact that a less depth of active material is worked upon by the acid, which tends to become weaker in the pores of the plates than in the bulk of the electrolyte owing to the quicker sulphation set up on the surface, which tends to restrict free circulation of the electrolyte in the deeper layers of the active material of the plates.

The negative plates having excess capacity, the capacity of the battery is that of the positive plates.

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Charge.—It is further essential to charge the battery intelligently. It would seem not uncommon to allow any odd amount of current, however small, to flow into the battery in order to keep the plant running at maximum efficiency, or to use the battery as a steadying load for the plant on light loads, notwithstanding that it is fully charged. Irremediable harm is liable to be done to the battery by such a policy. Low charging rates have a forming action on the positive plates, and excess charging is also harmful as the gassing produced scrubs the active material off the positive plates. The final volts per cell obtained during charge are also affected by the rate of charge.

The battery should be charged at the rate laid down by the makers, usually based on putting back the full capacity at the 10-hour rate in $5\frac{1}{2}$ hours, which is called the normal charging rate. When the cells begin to gas freely, this rate must be reduced to half normal, to obviate the scrubbing action mentioned above with violent gassing. There is no harm in exceeding the normal charging rate to the top rate allowed by the maker up to this point. Voltage readings on the cells must be taken with the charging current flowing; these should rise to 2·75 v. per cell during the extended charge. On open circuit this drops to about 2·05 v.

To obtain true specific gravity readings, they must be taken on open circuit, as the gassing in the electrolyte will give a false reading. With a view to maintaining homogeneity throughout the whole body of the electrolyte, the cells should preferably be topped up just prior to charging; only pure distilled water should be used for this purpose, and may with advantage be introduced into the bottom of the cell.

The range on the acid measured by the fall in the specific gravity at the 10-hour rate should be about 50°. The exhaustion of the battery can be gauged by the amount of fall in the specific gravity of the acid to which it is directly proportional, *e.g.*, if 50° is the correct range for the battery, and the specific gravity has fallen from 1215 to 1190, *i.e.* 25°, $\frac{25}{50}$ or one half the capacity of the battery is exhausted.

The ampère hour capacity of the battery is independent of the rate of discharge, and is 90 per cent. for a healthy battery before depreciation due to age or faulty operation and maintenance sets in. This means that normally the amount put back should be what has been taken out plus 10 per cent.

The wear and tear on a battery is reduced by not continuing the charge beyond this point for ordinary charges, and consequently the useful life of the battery is prolonged.

Once a week the battery should be given the extended charge, when all the symptoms of a fully charged battery should become manifest in a healthy battery. These are that the volts per cell,

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measured when the charging current is flowing, and the specific gravity have both ceased to rise for about an hour with further charging and are up to the figures given above. Any weak or defective cells should be detected during this extended charge and treated accordingly. The object of the weekly extended charge is to fully reduce every particle of sulphated active material, and to do this sufficiently often to prevent the formation of malignant sulphation difficult if not impossible to reduce.

It is useless to put back more, as is sometimes done in anticipation of a heavy discharge. The battery is like a jug in this respect; when it is full it is no use trying to pour more in, as it merely runs over the side to waste; so with the battery any unnecessary charging is merely dissipated in electrolysis and waste of the acid by the spray produced in gassing. Yet this is not so uncommon a procedure as one would suppose.

In working the battery, it will not suffice to go entirely by the ampère hour meters. These are only accurate up to a point, even if in correct adjustment, and such errors if cumulative may cause the battery to be persistently under- or over-charged. The cell voltmeter and hydrometer must be used as well to ensure that such is not the case.

In reading the hydrometer for purposes of comparison, the specific gravity of the acid must be corrected for temperature. The usual standard temperature taken is 60° F., and to compare readings they should be corrected by deducting 1° in specific gravity for every $2\frac{1}{2}$° F. rise, and by adding similarly for any fall in temperature below 60° F.

A point to take note of during charging is the gassing. Both plates should commence to gas simultaneously and both should gas freely as the charge proceeds. If the charge is interrupted both plates should gas immediately the charge is continued.

It is sometimes found that the negatives gas prematurely. This shows that they have become low in capacity and the reason should be sought.

Under no circumstances should a cell be allowed to become reversed in polarity. It is bad to allow a cell to run down to zero, but it is infinitely more harmful to allow the cell to become charged up in the wrong direction. Arrangements must be made to cut the cell out before this has occurred.

Regulating Cells.—It is a common fault in design to see these all grouped together at one end of the battery with no provision made for changing them over so that they can be made to form part of the battery for exercise. It is essential that arrangements be made for working these cells adequately, and this is not a difficult matter. Regulating cells should preferably be grouped at both ends of the battery.

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Necessity for Uniformity in a Battery.—Another and not uncommon fault, is to make up a battery with cells of unequal size and capacity. This is a bad and uneconomical arrangement. Suppose that a battery of 750 A.H. cells is extended with cells of 500 A.H. capacity. It is apparent that the 750 A.H. capacity cells will be insufficiently worked, with the result that they will get into a sluggish state and will eventually be reduced in capacity to 500 A.H. In charging too, it is apparent that the rate of charge is incorrect for one or the other, either the smaller capacity cell will be charged at too high a rate or the larger capacity cell will be charged at too low a rate.

Renewals.—It is also bad practice to renew the positive elements in cells in which the negatives have become deficient in efficiency.

Extensions.—Similarly it is most detrimental to increase the capacity of an old battery by the addition of new plates to existing elements.

Points to Guard Against in Maintenance.—The following extract, taken from Mr. E. C. McKinnon's invaluable articles on Storage Battery Management, gives the points to beware of in order to keep the battery in condition, and are reproduced by permission of The Chloride Electrical Storage Company, Ltd. :—

Failing to give the battery a proper initial charge.
Failing to give a new battery plenty of work and liberal charging.
Charging the battery too little.
Charging the battery too much.
Working the battery too little.
Running the battery too low in voltage and specific gravity between charges.
Running the battery too long between charges, irrespective of the amount of work done.
Charging the battery at too high rates, especially towards completion of charge.
Charging the battery at too low rates (less than half-normal).
Allowing the sediment to reach the bottom edges of the plates before having it removed.
Having the battery room too hot or letting too strong a breeze blow through the room, both of which cause an increase in the rate of evaporation.
Using unsuitable water to compensate for evaporation.
Not adding water sufficiently often to keep the plates always covered with electrolyte.
Adding any acid unwarranted by the condition of the plates or working conditions.
Using acid unsuitable in strength or purity.
Neglecting to observe the indications of irregular treatment.
Neglecting to attend to weak cells promptly.

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Failing to clear internal short circuits.

Allowing individual cells to be thoroughly exhausted (volts run down to zero).

Allowing individual cells to receive charge in the wrong direction with the rest of the cells on discharge.

In bolted up batteries, allowing the connections to become dirty, corroded, slack (which sets up heating and melting of the lead lugs).

Having the regulating switch discharge lever across a greater number of cells than that across the charge lever, during simultaneous charging and discharging.

There is a wealth of information underlying the above which the reader would do well to digest thoroughly, and then to critically examine his battery records to see how completely he avoids these pit-falls for the unwary.

If in spite of this, the cells become defective and the remedy is beyond the experience of the Engineer in charge, my advice is to call in without delay the W.D. Expert, the Chief Inspector of Royal Engineer Stores, for advice.

One more word of advice, do not use the Cadmium Testing Strip unless you know how to use it, otherwise you may get unreliable readings.

Records.—Records are generally regarded as a bugbear, but the necessity for keeping proper records of all charges, discharges, voltage, and specific gravity readings is an absolute essential, and is a point insisted upon by the Battery Makers in all Maintenance Agreements.

In conclusion I would acknowledge my indebtedness to Mr. E. C. McKinnon, A.M.I.E.E., of the Chloride Electric Storage Co., for the help he has given me in this subject, especially during the time I was on the Staff of the C.I.R.E.S.

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THE BATTLE OF THE SOMME.

R.E. PREPARATIONS IN THE 31ST DIVISIONAL AREA.

Extracts from the Report of LIEUT.-COLONEL J. P. MACKESY, D.S.O., R.E., *C.R.E., 31st Division.*

1. On 6th April, 1916, instructions were received that preparations must be made and completed by 30th April for attack against the German Lines.

As time was so short the work started at first was of a hasty nature and consisted mainly of clearing and opening up trenches which had been disused during the winter, and in constructing Divisional and Brigade Battle Headquarters and Observation Posts, Dressing Stations and Royal Artillery O.P.'s.

Later, when the date had been postponed, a more deliberate class of work was undertaken. The time available for preparation was however, curtailed through all possible men being for two weeks diverted to :—

(i.) Constructing or re-opening a new Front Line along the whole Divisional front.

(ii.) Constructing or re-opening a strong Second Line.

A long spell of wet weather considerably interfered with work in the trenches, and for the last week most of the Infantry were employed carrying ammunition, rations and gas cylinders to the front area.

2. The General Idea on which the preparations were based was that for the attack two brigades should be in front, with the third brigade close behind in reserve. The arrangements for work were complicated by having to garrison and prepare the trenches of a large area on the right which was to be occupied by another Division (the 4th) during the operations.

As the Division was holding only a brigade, or a brigade-and-a-half frontage, and brigades changed in and out of the trenches every eight days, it was difficult to secure continuity, and this was only obtained by keeping the Field Companies working steadily in the same areas.

3. The R.E. and Pioneer Battalion worked under the C.R.E., and were distributed for work as follows :—

Two Field Companies, R.E., each had a Pioneer Company placed at its disposal, and worked, one in the Forward Assembly Area of one Brigade and of the 4th Division, the other in the whole back Assembly Area of the third Brigade and of the 4th Division. The third Field Company had two Sections working in the forward Assembly Area of

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the second Brigade, and the other two sections were employed on back area work. The remainder of the Pioneer Battalion was employed as follows :—

One company assisting R.A. in the construction of gun emplacements and dug-outs, and in cutting trees for them ; one company on miscellaneous work, such as mending roads, sinking wells, constructing medium trench mortar emplacements and dug-outs, constructing Army and Corps Signal dug-outs and making horse standings and cross-country tracks.

4. The Divl. area was organized for the operations as follows :—

Four main avenues of communication led up to the dividing line between the reserve Brigade and the two front Brigades. This dividing line was a main lateral communication trench.

Beyond this line eight communication trenches led up to the front line, of which four were in each Brigade assembly area. Of these groups of four the two outside ones were allotted to forward traffic only and the two centre ones to return traffic only.

In each brigade area four dumps were constructed, each to hold rations and water for two days for one battalion. The rations and water were made up into men loads and put in covered recesses in assembly and disused trenches. One day's supply for a battalion occupied 432 cubic feet. Fifty thousand rounds S.A.A. were also stored at each dump.

R.E. dumps were formed as under :—

Four small ones at a short distance behind the Front Line ; two larger ones in rear of each Front Brigade Area ; one in Reserve Brigade Area ; and one large one as far forward as vehicles could go at night.

All the ration and R.E. dumps were placed between an up and a down trench for convenience of access. At least two deep dug-outs were constructed in the assembly trench of each battalion (except in the Front Line), and numerous other deep dug-outs were made in the Support and Reserve trenches of the front system. Two deep dug-outs, and in one case three, with an O.P. adjoining, were made for the Battle Headquarters of each Infantry Brigade in its assembly area.

Accommodation for a large number of wounded was provided by the construction of five large dug-outs, each ten feet by thirty feet, in rear of the Reserve Brigade assembly area, and five more large dug-outs, each ten feet by forty feet, at the advanced dressing station at Colincamps.

Two cross-country roads were marked out from Colincamps to the front trenches for the use of forward and return traffic. The trenches on the route were bridged to take motor ambulances, and several spare bridges were prepared to replace those broken by shells.

Every man was provided with a pick and shovel to carry on his

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person during the assault, and large numbers of wire-cutters, hedging gloves, mallets, trench ladders, trench bridges and sand-bags were issued to units.

5. The following is a summary of R.E. work done during this period of preparation :—

(i.) Eight miles of new trenches were made, including 10,630 yards of main approach trenches, 2,460 yards of communication trenches and 2,370 yards of assembly trenches ;

(ii.) Thirty miles of other trenches were cleared, deepened, repaired, improved and restored ;

(iii.) Eighty-six dug-outs were constructed (excluding those mentioned in xiv., xv. and xvi., below), details as under :—

No. constructed.	Type.	Thickness of earth on the top, in feet.	Superficial area, in sq. feet.
12	Curved Steel (Elephants)	5 to 10	2,800
42	Deep Mined.	14 to 20	5,000
31	Framed and Mined.	5 to 8	6,200
1	Special with 12½ feet headroom inside.	5	350
	Total		14,350

(iv.) Thirty-four Observation Posts were completed, viz. :—one for Army Survey, three for Division, four for Infantry Brigades, one for each Battalion, and 25 for R.A. ;

(v.) Thirty-six special emplacements for 360 gas cylinders were made in the front line ;

(vi.) Twenty-seven bridges were made over trenches to carry vehicles and motor ambulances, and four bridges to take heavy motor traffic over trenches on the Serre road ;

(vii.) One-and-a-half miles of steel tramway, with two intermediate sidings, were laid in a trench for taking up ammunition and evacuating wounded by day over open country ;

(viii.) Twenty-two Tramway trenches were made and a Tramway traffic control establishment formed ;

(ix.) Six sets of water tanks, to hold 3,250 gallons, were placed in trenches, and connected to water pipes ;

(x.) An engine and pump were installed in an old demolished farm, in the front area, where there was a deep well, and connections made to the water pipe system. During the operations this was the only water supply available in the trenches owing to the pipes of the main supply being continually broken by shells ;

(xi.) A Russian sap was started, but after progressing about 30 yards it was continually being blown up by trench mortar bombs and shells ;

(xii.) Twelve dumps were constructed to hold rations and water for 10,000 men for two days ;

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(xiii.) Two concrete and steel shell-proof shelters were erected over the main forward pumping station ;

(xiv.) Emplacements and dug-outs, not included in (iii.), were constructed for 21 Medium Trench Mortar batteries, close to the front line ;

(xv.) Dug-outs were made for 16 Batteries, R.F.A., which were not included in (iii.), also gun-pits ;

(xvi.) Five deep mined approaches (totalling 2,500 feet) were run to within 30 yards of the German Lines, and 20 Stokes' Mortar Emplacements were constructed off them in the middle of No Man's Land, for intensive bombardment prior to assault ;

(xvii.) Numerous Bangalore torpedoes, made of one inch piping, in 10 to 17 feet lengths, and filled with ammonal, were made and issued to the troops for use in raids, and to demolish the enemy's wire during the assault ;

(xviii.) Name boards and Notice boards were placed in all trenches, particularly at junctions and along cross-country road routes ;

6. The following work was, in addition, carried out in the back area :—

(i.) One hundred shelter huts were erected in a wood to accommodate four battalions, and four huts for the sick of a Field Ambulance ;

(ii.) Two wells were sunk 28 and 27 feet deep, and tanks and pumps were fixed to supply water to the above hutments ;

(iii.) Seven huts were built for officers, etc. ;

(iv.) Two deep wells were sunk to a depth of 130 feet each, with bore holes 130 feet below that, and motor pumps and tanks with stand pipes erected to fill water carts ;

(v.) Two reservoirs were constructed to hold 21,000 gallons, and 3½ miles of 4-inch piping were laid to form a water point, where troughs were erected to water 8,000 horses, and stand pipes to fill 75 water carts per day ;

(vi.) Two R.A. Ammunition dumps and one grenade and mortar dump were constructed ;

(vii.) 2,600 trees were cut down for making dug-outs and gun emplacements, and the branches were used for entanglements and revetment posts and for fascines ;

(viii.) Several cross-country roads were laid out and prepared for the movement of troops ;

(ix.) 2,500 yards of flint were quarried, which, with 1,300 yards of road metal, were used in repair of roads ; about 2,000 fascines were also made and used on the roads ;

(x.) An enclosure for Prisoners of War was erected. It was divided into three parts, for Officers, N.C.O.'s and men.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919—*continued.*

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Durham No. 1 Co. (W.) ... 1/1 526th Field Co. ,, ,, 2 ,, (W.) ... 1/2 527th Field Co. ,, ,, 3 ,, (W.) ... 1/3 528th Field Co.	These three 1st line Cos. were formed into Field Cos. Auth. 79/7634 (A.G. 1.) dated 22. 6. 15.	2/1 By 79/7634 (A.G.1.) of 22. 6. 15. these were to be raised with Imperial Service *personnel* to the establishments of 3rd line depôts of Field Cos., R.E., on higher establishment, shown in table A of 79/6988 (A.G.1.) of 25. 3. 15. 2/2 By 9/Engrs./7611 (A.G.7.) of 8.1.17, these units (with 2/1 E. Riding Field Co.) were designated 530th Durham Reserve Field Co., and belonged to the Northern Group Reserve Field Cos. A.C.I. 2420 of 1916. The Northern Group was subsequently reorganized by 20/Engrs./5214 (A.G.7.) of 12. 1. 18, and *personnel* 2/3 distributed to 4th Reserve Battn. and R. Monmouth Reserve Battn., R.E.	There was no authority under 79/7634 (A.G.1.) of 22. 6. 15 for the formation of 3rd line Cos. for the Durham Fortress, but owing to some misunderstanding in the N. Command three Cos. were formed and existed as Nos. 1, 2 and 3 Cos., Durham Fort. R.E. They can therefore only be regarded as 3rd line Cos. After some discussion on 9/Engrs./8162, it was decided, in view of the impending reorganization of R.E. Coast Defence units, to allow them to remain until absorbed. The reorganization took place by 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18, and the three Cos. were disposed of as follows: No. 1 Co. was merged into 16th Tyne Fort. Works Co. No. 2 Co. was merged (with 1/1 and 2/1 N. Riding) into 595th Tees Fort Co. No. 3 Co. was merged partly into 594th (Tyne) Fort Co. and 16th (Tyne) Fort. Works Co.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
N. Riding E.L. Co. ...	... 1/1 and 2/1 595th Tees Fortress Co., No2 Durham Fort. Co.,was also absorbed into 595th Co. 20/Engrs./5215 (A.G.7.b.) of 10.6.18. *Note.*—(There was no auth. under 79/7634 (A.G.1.) of 22.6.15 for the existence of the Durham Co. See note against Durham Fortress 3rd Line.)	2/1 was merged with 1/1 into 595th (Tees) Fortress Co., R.E.	No 3rd line formed.
E. Riding No. 1 Co. (W.)	... 1/1 529th Field Co. Auth. for formation into Field Co. 79/7634 (A.G.1.), 22.6.15.	2/1 raised to establishment of 3rd line depôt of a Field Co. on higher establishment as in Table A of 79/6988 A.G.1. of 25. 3. 15. See 79/7634 (A.G.1.) of 22. 6. 15. Subsequently merged into 530th Durham Reserve Field Co. (A.C.1.) 2420 of 1916. See 2nd line of Durham R.E. for later developments.	No 3rd line formed.
E. Riding No. 2 (E.L.) ...	... 1/2 Amalgamated with 596, 597 and 581st Works Cos.		
Hampshire No. 1 Co. (W.)	... 1/1 559th A.T. Co. Converted into an A.T. Co. for Medn. E.F. 20/Engrs./5073.	2/1 561st (Works) Co. The formation of this was approved on 9/Engrs./4125.	No 3rd line formed.
,, ,, 2 ,, (W.)	... 1/2 560th A.T. Co.	2/2 562 (Works) Co. Disbandment ordered by 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19.	No 3rd line formed.
,, ,, 3 ,, (W.)	... 1/3 563rd Works Co. Reduction to Cadre of 1 officer, 8 other ranks, ordered by 20/Engrs./5382 (A.G.7.b.) of 2.4.19., but disbanded 17.6.19. 20/Engrs./5334.	2/3 564th Works Co. The formation of this was approved on 9/Engrs./4125. Being disbanded 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19.	No 3rd line formed.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line
Hampshire No. 4 Co. (E.L.) ...	1/4 and 2/4 Amalgamated with 603, 604 and 605th (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10.6.18.	2/4, 2/5, 2/6 and 2/8 reorganized with 1st lines into 603rd, 604th and 605th (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.	No 3rd lines formed for 1/4, 1/5, or 1/6.
,, ,, 5 ,, (E.L.) ...	1/5 and 2/5 Amalgamated with 603, 604 and 605 (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10.6.18.		
,, ,, 6 ,, (E.L.) ...	1/6 and 2/6 Amalgamated with 603, 604 and 605th (Portsmouth) Fortress Cos. 20/Engrs./5215 (A.G.7.b.) of 10.6.18.		
,, ,, 7 ,, (Works) ... (Not pre-war.)	1/7 506th (Hants) Field Co. Auth. for conversion to Field Co. 79/7634 (A.G.1.) d. 22.6.15.	2/7 was raised with Imperial Service *personnel* to the establishment of 3rd line depôt of a Field Co. on higher establishment (shown in Table A of 79/6988 (A.G.1.) of 29. 3. 15) by 79/7634 (A.G.1.) of 22. 6. 15. Subsequently absorbed into 508th Wessex Reserve Field Co. See Wessex Divl. R.E.	No 3rd line formed.
,, ,, 8 ,, (E.L.) ... (Not pre-war.)	1/8 and 2/8 Amalgamated with 603, 604 and 605th (Portsmouth) Fortress Cos.	See 1st line.	No 3rd line formed.
Fortress R.E. (T.).			
Wiltshire Works Co.	1/1 565th (Wilts) A.T. Co., France.	2/1 566th (Wilts) Works Co. (Disbandment has been ordered by 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19.	No 3rd line formed.
Dorset E.L. Co.	1/1 606th (Portland) Fort. Co. (20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.)	2/1 Absorbed (with 1/1) into 606th (Portland) Fortress Co.	No 3rd line formed.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914. TO FEBRUARY, 1919.

Pre War Unit.	Present 1st Line.	Present and Line.	Present 3rd Line.
Devon No. 1 Co. (W.) ...	... 1/1 567th (Devon) A.T. Co. (Gibraltar 12. 12. 14 to 24. 3. 15 as a Works Co., France 24. 6. 15 as an A.T. Co. Selected for Army of Rhine 121/France/3384.)	2/1 570 (Devon) A.T.Co.	Regarded as Cadres for Reserve Army Troops Cos. by 121/9015 A.G.7 of 12. 6. 17. Converted to A.T. Co. by 121/8547 (Mob 1.), of 29. 8. 17. at W.E. 351/43, Part VII., 1916, for service in Egypt. Embarked for Egypt 26. 9. 17.	No 3rd line formed.
,, ,, 2 ,, (W.) ...	... 1/2 568th (Devon) A.T. Co. (Gibraltar 24. 3. 15 to 29. 10. 16 as a Works Co., France 13. 3. 17 as an A.T. Co.)	2/2 571st (Devon)A.T.Co.	Required for Army of Occupation, Egypt, G.B./8212 (A.G.7.b.).	No 3rd line formed.
,, ,, 3 ,, (W.) ...	... 1/3 569th (Devon) A.T. Co. Egypt. (Now reduced to cadre "A" G.B./8212 (A.G.7.b.)).	2/3 572nd (Devon Works Co. To France 5. 8. 18 as a Works Co,		No 3rd line formed.
,, ,, 4 ,, (W.) ...	... 1/4 616th (Devon) Fort. Co. To Gibraltar in 1915.	2/4 Merged into 607th and 30th (Plymouth) Fortress Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		No 3rd line formed.
,, ,, 5 ,, (E.L.) ...	... 1/5 Amalgamated with 607 and 30th (Plymouth) Fortress Cos.	2/5 Merged into 607th and 30th (Plymouth) Fortress Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		No 3rd line formed.
Cornwall No. 1 Co. (E.L.)	... 1/1 608th (Falmouth) Fortress Co. (Reorganized by 20/Engrs. 5215 (A.G.7.b.) of 10. 6. 18.)	2/1 Merged (with 1/1 and one Section of 18th Co., R.E. Regulars) into 608th (Falmouth) Fortress Co., R.E. 20/Engrs./5215 A.G.7.b.) of 10. 6. 18.		No 3rd line formed.
,, ,, 2 (W.)	... 1/2 573rd (Cornwall) A.T. Co., France 24. 1. 15. Selected for Army of Rhine. See 121/France/3384. G.B./8315 (A.G.7.b.)	2/2 575 (*Cornwall*) *Works Co.* Mobilization by 121/France/2467 (Mob. 1.) of 13. 7. 18, at W.E., page 155 of W.E. Part XIV. (Home) except 2 Bugrs. To France 27. 8. 18.		No 3rd line formed.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.	Present 2nd Line.	Present 3rd Line.
Cornwall No. 3 Co. (W.) ...	1/3 574th (Cornwall) A.T. Co., France, 4. 4. 15.	2/3 576 (*Cornwall*) *Works Co.* Disbandment ordered by 20/Engrs./5382 (A.G.7.b.) of 2. 4. 19	No 3rd line formed.
Essex E.L. Co.	The Essex Fort, R.E., amalgamated with 21st (Harwich) Fort. Co., R.E. 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18.		
Kent No. 1 Co. (W.)	1/1 495th Field Co. (Authority for formation into a Field Co. is 79/7634 (A.G. 1.) of 22. 6. 15.)	2/1. By 79/7634 A.G.1. of 22. 6. 15 these units were raised to the establishment of 3rd Line Depôts of a Field Co. on the higher establishment shown in the Table "A" of 79/6988 (A.G.1.) of 25. 3. 15.	No 3rd line formed.
,, ,, 2 ,, (W.)	1/2 496th Field Co.	2/2. They formed part of the Eastern Group Reserve Field Cos., A.C.I. 2420 of 1916, and merged into 499th (Home Counties) Reserve Field Co. 9/Engrs./7611 (A.G.7.) of 8. 1. 17.	No 3rd line formed.
,, ,, 3 ,, (W.)	1/3 497th Field Co.	2/3. On the reorganization of R.E. Reserve Battns. by 20/Engrs./5214 A.G.7.b.) of 12. 1. 18, the Eastern Group Reserve Field Cos. merged into 5th Reserve Battn., Christchurch, which has been disbanded 15. 3. 19. 20/Engrs./5323.	No 3rd line formed.
,, ,, 4 ,, (W.)	1/4,2/4 Reorganized under 20/Engrs/5215 (A.G.7.b.) of 10. 6. 18 into 598th Thames and Medway Fort. Co., R.E. Some of the *personnel* may have been merged into the 580th Thames and Medway Fort. Works Co. It is hardly likely that Kent Fort. *personnel* were transferred to 599th (T. and M.) Fort: Co., London Electrical Engrs., which was formed mostly from No. 2 Co., London E.E.		
,, ,, 5 ,, (E.L.)	1/5, 2/5	See 1st line.	No 3rd line formed.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919.

Pre-War Unit.	Present 1st Line.		Present 2nd Line.	Present 3rd Line.
Kent No. 6 Co. (W.) ... ... (Not pre-war.)	1/6 546th Field Co.	These units were converted to Field Cos. for the 73rd H.S. Div. 79/9368. When the 73rd Div. was broken up (20/G.N./4833 (A.G.1.)of 22.12.17 20/Engrs./5237, G.B./4681 (A.G.7.) & 114/G.N./5763) the Cos. were on aerodrome work. Later the 546th and 547th were re-mobilized for the new 72nd Div. (at W.E. 627,Part VII. A of 1. 8. 17. and embarked for France 22. 6. 18.	2/6 579th (Kent) Works Co. absorbed into 580th (Thames andMedway) Fort. Works Co. by 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18. See below.	No 3rd line formed.
,, ,, 7 ,, (W.) ... ... (Not pre-war.)	1/7 547th Field Co.		2/7 580th (Thames and Medway) Fort. Works Co. (formerly Works Co.). Also absorbed 579th (Kent) Works Co. 20/Engrs./5215 (A G.7.b.) of 10 6. 18.	No 3rd line formed.
Cinque Ports E.L. Co. 1. ...	1/1 and 2/1 Amalgamated with 600th Dover Fortress Co., R.E. (20/Engrs./5215) (A.G.7.b.) of 10. 6. 18.		2/1. See 1st line. Reorganized and designated (with 1/1) 600th (Dover) Fort. Co., R.E. 20/Engrs./5215 (A.G..7b.) of 10. 6. 18.	No 3rd line formed.
Sussex Works Co.	1/1 577th (Sussex) A.T. Co. Went to France.		2/1 578th (Sussex) Works Co. Mobilization at W.E. page 155 of Part XIV., 1918, less 2 Buglers by 121/France/2467 (Mob. 1.a.) of 22. 8. 18., at Newhaven. Embarked for France as a Works Co. on 9. 9. 18.	No 3rd line formed.

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R.E., T.F., REORGANIZATION SINCE AUGUST, 1914, TO FEBRUARY, 1919

Pre-War Unit.		
London Electrical Engrs.		
No. 1 Co.	Absorbed with Devon R.E., etc. with 607th and 30th (Plymouth) Fort. Cos.	Peace Establishments, Part II., 1913—14, of London E.E., was 21 officers and 447 other ranks. 9/Engrs./1644 (T.F.1.) of 11. 10. 14 authorized an increase of 50% N.C.O.'s and men (that is authority to form a Home Service Unit). 9/Engrs./1825 (A.G.7.) of 17. 11. 14 authorized an increase of 173 other ranks to the original establishment of 447, making the establishment of 620 and for the 50% increase of establishment authorized by A.O. 399 of 1914, to be calculated on this increased establishment, making it 620+50%=930 other ranks. For details of ranks see (9/Engrs./1969 of 12. 12. 14. 9/Engrs./2748 (T.F.3.) of 29. 7. 15 authorized an increase of establishment of London E.E. of two majors for combined 1st and 2nd lines, and to be temporary only. 9/Engrs./2131 (A.G.7.) of 19. 6. 15 authorized an increase of total War Establishment E.L. Cos. of London E.E., to be increased by 8 subalterns to provide for extra lights for fixed defences and A.A. Guns. 79/8494 (A.G.7.) of 25. 12. 15 and 11. 1. 16 authorized a total establishment of 74 officers, 2,030 other ranks, inclusive of 1st and 2nd lines, and amended W.O. letter 79/7634 (A.G.1.) of 22. 6. 15 by deleting the numerals in Columns 4 and 6 of that letter (*i.e.*, designations 1st and 2nd line Cos.) and inserting the words "Special Establishment." In addition to its functions in Garrisons, the London E.E. formed A.A.S.L. Cos. The A.A.S.L. Cos. have been reorganized as separate units, but the London and Tyne E.E. are parent units of all *personnel* attached to R.G.A. Anti-Aircraft Cos. The establishment of the London E.E. is under consideration on G.B./9018 (A.G.7.b.) The re-formation of T.F. Headquarters has been dealt with on 9/Engrs./8392.
,, 2 ,, ...	Absorbed into 599th (Thames and Medway) Works Co.	
,, 3 ,, ...	Was reorganized as 601st (Dover) Fortress Co., London E.E., by 20/Engrs./5215 (A.G.7.b.) of 10. 6. 18, but 601st Co. subsequently disbanded by 20/Engrs./5305 (A.G.7.b.) of 5. 8. 18.	
,, 4 ,, ...	602nd (Newhaven) Fortress Co. London E.E. 20/Engrs./5215.	
,, 5 ,, ...	615th Fortress Co. London E.E.	
,, 6 ,, ...	Became No. 6 A.A.S.L. Co., R.E. 29. 7. 16, but was disbanded 26. 1. 18 and used to form Nos. 10—12 A.A.S.L. Cos., R.E. 20/Engrs./5266.	

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Pre-War Unit.	
Eng. and Railway Staff Corps ...	This only consists of officers—none below rank of Major—establishment about 60, and is administered by S.R.I.a. not A.G.7.
Army Postal Service (T.F.) ...	The establishment of the A.P.S. (T.F.) was published by War Office letter 79/4941 (A.G.7.) of 12. 9. 14. Substantial modificationwas subsequently approved on War Office files 91/Engrs./1148, 91/Engrs./1193, 9/Engrs./8115 and 79/77. The amalgamation of the A.P.S. (T.F.) with the R.E. Postal Section was recommended in letter from D.A.P.S. (Home), dated 26. 4. 18, in 20/Engrs./5259, and again in October, 1918, on 9/Engrs./8333, but no decision was given. A further letter, d. 11. 4. 19, from D.A.P.S. (Home), which is being dealt with on 9/Engrs./8333, states unit has been disembodied with exception of a small Cadre (and 20 volunteers for Army of Rhine, who have been posted to R.E.P.S.), which has completed demobilization functions. It is asked whether the unit is to be disembodied or retained as a distinct organization from R.E.P.S.

[*The List of R.E.T.F. Organization was commenced in the October number of* R.E. JOURNAL, *page* 182, *and continued in the November number, page* 225.]

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THE DEVELOPMENT OF THE WORKS DIRECTORATE, MESOPOTAMIA EXPEDITIONARY FORCE.

PART I.—BUSRA, AND THE LINES OF COMMUNICATION.

Compiled from Notes supplied by COLONEL D. K. EDGAR, D.S.O., *Director of Works, M.E.F.*

THE original Expeditionary Force dispatched from India in the autumn of 1914 contained no organization for Works on the Lines of Communication, and at first all construction was carried out by Field Engineers and Sapper and Miner Companies, with the assistance of such local labour as the country could supply, and such fatigue parties as regiments and depôts could spare.

Busra, which was occupied on 22nd November, includes the native city, lying about three miles south of the Shatt-el-Arab, with which it is connected by the Ashar Creek, the Ashar Bazar at the mouth of the Creek, and a few houses along the bank of the Shatt-el-Arab, the property of European firms and rich local Arabs.

After the occupation, the main administrative area was sited to the south of the Ashar Creek. G.H.Q. was located in the British Consulate, the L. of C. headquarters and Base Commandant took over the house of a local German, the Supply and Transport had a brick building close by, and the Turkish Commodore's house was allotted to the R.E. services and became Royal Engineers House. The Ordnance branch and the Telegraph Department were accommodated in two other brick buildings in the neighbourhood. The Turkish Infantry Barracks in Ashar became the British Base Depôt, and the Naval Barracks were turned into the Indian Base Depôt. In addition, three or four large buildings about a mile above the mouth of the Creek were lent by the Sheikh of Mohammerah for use as hospitals.

For the Engineer Field Park the original suggestion was the tennis court of the German Consulate, but eventually a site on the south side of Engineers House was selected, and here some stores hastily purchased by the Divisional Engineer Commander, Lieut.-Colonel (afterwards Brig.-General) U. W. Evans, on his passage through Bombay, were accommodated. They were landed from the steamer into Mahelas (dhows of various sizes), and thence carried to the only pier then existing at Busra, and there unloaded and stacked by working

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parties. The staff of the Park consisted of one officer, one staff-sergeant, and one native sapper, and their office was a shed improvised from casks and roofed with corrugated iron. The Park in 1918 covered 52 acres, and its workshops alone covered nearly 36,000 sq. ft. and contained machinery valued at 2½ lakhs of rupees.

The work of providing shelter for troops and sick was put in hand at once and by the end of 1914 hospital accommodation for 650 British and 850 Indians, and troop accommodation for 2,255 British and 5,675 Indians was provided. Materials in large quantities were purchased from local contractors after the beginning of December, and included timber, both sawn and in spars, and some iron and hardware. These contractors were subsequently encouraged to keep stocks of materials as a useful reserve in case of necessity.

In March a Works Company arrived from India, and the Works Directorate may be said to have commenced operations under a Deputy Director, Major A. F. Cumberlege, but up to the end of 1915 all work was carried out by local labour and the services of local contractors were utilized in the construction of rough huts for the accommodation of troops.

During the spring of 1915 one of the chief difficulties to be contended with in Mesopotamia was experienced for the first time. In that year the floods were exceptionally early and high. The whole camping area of Makina, a mile or two from the Shatt-el-Arab, was flooded by the waters of the Euphrates, which overflowed its banks and covered the desert between Busra and Shaiba. At Busra the problem of protection from floods was taken in hand during the summer of 1915. A protective bund, about ten miles long, from Magil on the Shatt-el-Arab some five miles above the mouth of the Ashar Creek, to Shaiba, was sanctioned, and also the road from Busra to Zobeir, which now carries the railway, and which was to be raised above flood level. These bunds were designed to enclose an area of 45 square miles, and include all the camping grounds around Busra.

The original design of the Shaiba bund provided for a bank averaging 6½ ft. high and 10 ft. wide at the top, with side slopes of 1 in 2½ The top was calculated to be 5½ ft. above high flood level.

Owing to the difficulty of obtaining labour it was not possible to start work until the end of October. Even then work progressed very slowly, and up to the end of January, 1916, the average number of coolies employed was only 350, in spite of the orders of the Army Commander to the Chief Political Officer to impress Civil labour. In February numbers increased to 3,000, but it was necessary to place the coolies under a guard to prevent desertion. Owing to these delays it was not possible to complete the bund to its full section, and when on the 19th April the flood water from the Euphrates came up, it was very weak in places. To protect its face against wave

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action revetting by means of mats, pegged down, was tried, but these were torn away and the earth scoured out behind them. Sand-bag revetment proved a failure, as the fine silt of the desert was washed out of the bags in a few hours when exposed to the waves. Eventually the whole face of the bund for a length of about six miles was revetted with corrugated iron sheets, backed with mats and sandbags. At this time 2,000 troops and half a Labour Corps, in addition to the Arabs, were working on the bund. In June and July the water subsided. Before the flood season of 1917 the bund was brought up to full section and the front slope decreased to 1 in 5. The corrugated iron was left in it as an additional protection. No flooding occurred during 1917, and before the spring of 1918 a wave-breaking fence had been erected and the face of the bund protected by mats and fascines of reeds. Experiments were made to induce vegetation, reeds and trees, to grow along the toe of the bund, but none of these protective methods proved efficient, and finally the whole of the front face was covered with six inches of coarse sand from Shaiba Ridge, which successfully withstood the floods of 1919, when the erosion was very small.

To return to the conditions of the first year of the war. On the capture of Busra, roads were practically non-existent, the inhabitants travelling about along the various creeks, which intersect the palm gardens, in local boats, called bellums.

A Turkish bridge existed over the Ashar Creek to Ashar Bazaar, but this was not strong enough to take heavy loads, and was replaced by a stronger bridge, designed to take loaded motor lorries, and constructed by a Sapper and Miner Company. An unmetalled road was opened up through Ashar Bazaar and across two creeks, the Khandag and the Robat, to Makina. With the increase of the force it was soon found that the restricted area along the river front and Ashar was insufficient, and a scheme for transferring the Ordnance and S. and T. Depôts to Magil was projected. A few temporary jetties were built there, and a road was constructed connecting Makina and Magil.

The only piped water supply which existed in Busra was a line delivering water from a small engine and pump on the bank of the Shatt-el-Arab to the Turkish Barracks at Ashar. Other camps and billets drew their water from the centre of the river in tanks, loaded in bellums. Early action was taken to prepare schemes, and material was ordered to provide a water supply for Makina, Magil, Ashar, and the River Front Areas.

The maintenance of roads, which eventually reached a length of nearly 40 miles in the Base alone, presented many difficulties. As no stone was procurable locally the roads were built of earth, raised on embankments above flood level. The soil of the country is very fine silt, which cuts up badly under traffic. During the rains the roads

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became quagmires, and although improvements were tried by laying palm leaves and reeds on them, transport became practically impossible during the winter of 1915—16. So bad did the roads become that the Army Commander ordered 14,000 tons of road metal from India, for the purpose of providing one main metalled thoroughfare between the River Front Area and Magil, *viâ* Makina. This stone arrived in April and May, 1916, and was off-loaded and stacked in various depôts near the river, but owing to transport difficulties it was not possible to start using it before the autumn of 1916.

Experience showed the necessity of electric lights and fans during the hot weather, and an order was placed for material to provide these for hospitals totalling 7,000 beds. Meanwhile the Searchlight Section was able to obtain and erect five small lighting sets, which provided a limited amount of power for the British Hospital, G.H.Q., Ashar Barracks, and H.Q., L. of C.

At the end of 1915 the Works Directorate had representatives at Busra, Kurna, Amara, and Ahwaz, and had a very extensive building programme ahead, with a very limited amount of *personnel*. But early in 1916 additional labour and officers began to arrive. In January the 2nd Labour Corps arrived from India and was followed shortly by the 1st Labour Corps which had been in Egypt. The 3rd, 4th and 5th Corps arrived shortly afterwards. Later in the year the 2nd Corps was sent up country, and approval was given for the Director of Works to enter into an agreement with an Indian labour contractor to supply 1,100 labourers with a proportion of artificers. Some of these men arrived in September and were of the greatest value. Eventually this corps, known as Fadooany's Coolies, became the nucleus of the 9th Corps. A proportion of the artificers were Chinese carpenters, and were not altogether a success, owing to various causes.

At the end of January, 1916, an Electrical and Mechanical Section was formed from *personnel* of the Searchlight Company and placed under a D.A.D.W., who shortly became A.D.W. In March the title of A.F.E. in charge of the Engineer Field Park was changed to A.D.W. Park, and the Field Park became an integral part of the Works Directorate. At the end of April Col. E. R. B. Stokes-Roberts became D.D.W., and in August he was made Director of Works with the rank of Brigadier-General. In September a War Establishment of the Directorate and Works Companies was submitted which provided for 32 officers, including six A.D.W.'s.

During the first seven months of 1916 the hospital accommodation was increased by 4,710 beds, and additional hutting for 14,750 troops was constructed. In addition, 8 miles of new roads were made in Busra and nine bridges were built to carry heavy traffic.

With the stone from India there arrived two 6-ton steam rollers, their size being limited by the strength of the bridges, which had not

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been constructed to carry loads greater than eight tons. When at last it was possible to commence spreading the metal, it was found that the hard Bombay trap would not consolidate under these rollers, and the road could not be built under ordinary methods. The winter rains were approaching and the matter was becoming urgent when the idea was conceived of binding the metal with concrete. An experiment was made of laying the metal dry and grouting in with sand and cement in a mixture of 1½ to 1. It was found that layers of broken stone, 4 inches deep, could be grouted successfully, so that all interstices were filled. The progress by this method was much faster than by mixing concrete in the ordinary fashion, and it was adopted. The thickness of the slab varied from 8 in. to 4 in., dependent on the stability of the surface below.

It was soon found necessary to supplement the Indian stone, as the quantity was insufficient, and steps were taken to investigate, and if possible, develop, any sources of local supply, to provide for immediate and future requirements. Jabal Sanam, a hill about 25 miles S.W. of Busra was visited in September, 1916, but although a certain amount of good stone was to be found there, it was not considered a feasible source of supply at the time, owing to the difficulty of transport into Busra, and meanwhile arrangements were made to obtain stone from Koweit in native craft. This lime stone proved quite useful as road metal, but the supply was uncertain and very limited. A small amount of sandstone was also brought from near Ahwaz.

In October, 1916, it was reported that a good limestone was to be found on Kharaq Island, situated 30 miles from Bushire and 90 from Fao. The Director of Works inspected the island and decided to develop it as a source of supply. But meanwhile a report came in that stone was found in the desert, near the railway, between Busra and Nasiriyeh, and in December investigations were made at El Jalib and Legait, and ten miles S.W. of Tel-el-Lahm, but they revealed only a very poor class of sandstone, which was of no practical value for road work where heavy traffic was involved.

The first quarry party, consisting of 250 men of the 5th Labour Corps, consequently, sailed for Kharaq Island in February, 1917, and from that time this became the principal source of supply The work was soon taken over by Persian labour In all about 28,000 tons of stone were imported, almost entirely in native craft, of which over 170 boats were employed on this work. The maximum export in a single month was 3,100 tons (100,000 c.f.). A jetty was made to accommodate boats drawing up to 14 ft. of water, and about four miles of tramway laid, the haulage being done by mules imported into the island. A camp was made, and a wireless station erected, giving communication with Busra. The main difficulty in connection with this source of supply was the uncertainty of transport,

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which practically ceased during the winter months. Transport also proved a very heavy item in the cost of the stone at Busra.

During the spring of 1916 the floods were extremely high; and in spite of bunds along the banks of the river and creeks, much damage was done. Many of these bunds were merely mud walls, and these were often breached and whole areas of date gardens were flooded to a depth of three to four feet, through which the raised roads ran like causeways across a marsh. Around the more important areas occupied by buildings earthen bunds of good section were constructed, but even these were powerless to keep the enclosed areas dry on account of the percolation of the water through the soil. Pumps were installed in various places to deal with the soakage water, but this method could not be considered a permanent arrangement. Since the whole country was level and cultivated to a depth of 2 to 3 miles from the river it was not possible to obtain earth for reclamation purposes in the vicinity, and as the ground had to be raised to a safe level before buildings could be constructed on it it was decided to lay down a light railway to bring the necessary earth from the desert. Forty miles of track, 10 locomotives, and 850 trucks were ordered from India, and in September, 1916, a Reclamation Section of the Works Directorate was formed. Meanwhile, pending the arrival of the material and equipment for the line, all earth for filling was obtained either from borrow pits—which will eventually have to be filled in again—or brought by small native craft from long distances up creeks, but the first of these methods was insanitary, as the pits could not be drained, and the other slow and laborious. There were in Busra ten miles of 9-lb. track with four motor tractors, which had arrived from England about August, 1916, and this was laid to assist in the distribution of the road metal referred to above, and formed the first lines of the Reclamation system. This 9-lb. track proved too light even for motor tractors, and was replaced as soon as the heavier rails began to arrive from India in October.

The War Establishment of the Reclamation Section, under an A.D.W., was put forward in September, and in October an officer was sent to India to recruit the necessary *personnel*. On the arrival of these men work was pushed on, and by the end of the year platelaying was progressing favourably. As all material, both of permanent way and rolling stock, was secondhand, considerable repairs were necessary, and in January, 1917, a further order for material was sent to India, as it was foreseen that the amount of work to be done could not be handled by the existing stock. A line connecting the river front with Makina was laid to facilitate the distribution of stores and release motor lorries for the forward areas.

After the fall of Baghdad a large proportion of the rolling stock and *personnel* were sent up country, and the progress of the Reclamation line was severely handicapped. In the hot weather of 1917

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the work was further delayed by sickness, and it was not till October, 1917, that the project as originally designed was nearing completion. The construction work had been heavy. The permanent way had to be laid on high embankments above flood level, many bridges had to be built across the numerous creeks, repair shops for locos. and rolling stock had to be erected, quarters for staff and numerous other arrangements made, all of which had been accomplished only by the hard work and devotion of the officers and men of the Section. On 14th October, 1917, the Reclamation Railway was handed over with its staff to the Railway Directorate, and passed out of the control of Works.

During 1916 the Medical Authorities took great pains to ensure that the water used by the troops was purified before use. The usual method was to pump the water into an expense tank and add a specified amount of bleaching powder, after which the water was allowed to stand half-an-hour before being drawn off. Towards the end of 1916 Lieut. Myers, I.A.R.O. designed an automatic suction chlorinator for attachment to the pumps used for drinking water. A small tank containing bleaching powder solution was connected through a needle-valve with the suction pipe of the pump. The suction of the pump drew in a small amount of solution with the water. As practically all the pumps were centrifugal, the bleach solution and water were intimately mixed during their passage through the pump. It was found that in all installations the passage of the water through the rising main and overhead tank to the consumer took more than the half-hour necessary for the solution to purify the water. The percentage of solution added to the water could be accurately controlled by adjusting the needle-valve. The system was improved by several officers, and was brought into use at all pumping stations throughout the country.

Owing to the deterioration and shortage of the stocks of bleaching powder it was decided towards the end of 1917 to undertake its manufacture by electrolysis. This was commenced at Baghdad and was successful after a few experiments, at a lower cost than that at which the bleaching powder could be imported. The manufacture was extended to Busra in the following autumn.

The experience of the hot weather of 1915 showed the necessity of providing electric light and fans for all hospitals, British and Indian. The original order for plant to supply 7,000 beds was complied with and the work of erection was well in hand by the hot weather of 1916. At the end of July India was informed that installations for an additional 7,000 beds would be required, and it was decided that a central power station should be erected in Busra. In September Major Pitkeathy arrived as A.D.W., E. and M. A certain amount of steam generating plant was immediately available in

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India, and the power station was designed to utilize this, the rest of the plant being ordered from England.

Owing to the short time available for construction, it was decided to erect a station with both alternating current high-tension and direct current three-wire plant.

The plant available in India consisted of two complete steam-driven alternators, each of 130 kilo-watts at 3,000 volts, with Babcocks and Wilcox boilers, chimney, switch-board, and all accessories, intended as a stand-by plant for the Kashmir durbar; two 120 kilo-watt 440 volt continuous current dynamos from the North-Western Railway of India, with a few accessories and four Babcocks and Wilcox boilers, with chimney, under construction for a textile firm in Bombay. It was proposed to have the Kashmir alternators rewound to 6,600 volts, but this was not found practicable, and 3,000 volts had to be accepted as the generating voltage. To economise in engine power it was decided to fit two continuous current dynamos in tender with the Kashmir alternators. Additional plant ordered from England for the station consisted of two 250 kilo-watt continuous current dynamos, a 200 kilo-watt alternator and a 150 kilo-watt rotary convertor.

The site decided for the central power station was on Ashar Creek. It was acquired at the end of September, 1916, and work was at once started clearing the palm trees, laying foundations and raising the ground to above flood level.

The power station was designed to supply power to the hospitals, the River Front area, Basra city and Ashar, on 440 volts, three wires; three sub-stations being provided at Magil, Makina, and Tanooma to convert high-tension alternating current to continuous current, to suit the existing current consuming devices. The sub-station machines with all necessary accessories were ordered from England.

A misfortune occurred in the loss of the ship carrying a large proportion of this plant. Steps were taken by the War Office to replace the losses immediately, but as the new plant could not arrive in time for the hot weather, it was necessary to get more plant from India. The scheme was considerably modified and by this means the Central Power Station commenced taking the load in March, 1917, releasing small plants for re-erection up-river. The duplicate plant arrived during the hot weather and was shipped to Baghdad and erected there.

The site was further designed to include a well-equipped workshop, an ice factory and cold store. The demand for ice in the Force had increased enormously, and the sanctioned programme for the hot weather of 1917 allowed for the manufacture of 40 tons daily. The factory at Busra was designed to make 20 tons a day, with an ice-store to hold 250 tons. Several one-ton plants were mounted

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on barges for use of the troops in the field, and new plants were erected at various stations.

By February, 1917, the responsibilities of the Director of Works had so greatly increased that his staff now included two Deputy Directors and eleven assistants. The latter were distributed as follows:—One on the D.W. Headquarter Staff; one in charge of Electricity and Machinery; one in charge of the Park; and one in charge of each of the following districts:—River Front, Magil, Reclamation, Euphrates Line, Kurna, Amara, Sheikh Saad, and Tigris Road.

The history of the Tigris road is interesting. On 18th January, 1916, instructions were received to construct a raised road above flood level along the river bank from Kurna to Amara. A certain amount of preliminary reconnaissance was necessary and arrangements for material and labour had to be made, and it was not until the 15th February that working parties were detailed to proceed from Busra. The distance by road from Kurna to Amara is 70 miles, and 2,200 men were detailed to five sections of the road. In addition to the working parties the political officers endeavoured to collect Arabs, and eventually from 3,000 to 4,000 were got to work. Between Kurna and Mantaris, a distance of about 35 miles, the road lay almost entirely along low swampy ground, which entailed the construction of an embankment three to four ft. high to keep the road above high flood level. In addition, many creeks, which drained the swamps, had to be bridged, and the whole work had to be completed before the flood season at the end of April. Instructions were received to make the bridges capable of taking a 3-ton load, representing a Fiat lorry fully loaded.

In order to obtain the maximum benefit of this road it was decided to extend it to a point six miles below Kurna, where steamers up to 12 ft. draught could proceed, and land troops and material. Early in March three landing-stages were constructed at Steamer Point, and the road constructed from there to Kurna. This entailed a considerable amount of earth work and bridging, which was carried out by the 71st Field Company, R.E. A pontoon bridge was thrown across the Euphrates as a temporary measure, and was afterwards replaced by a bridge of bellums or small native craft. Work on the road was pushed on rapidly. No. 4 Company Sappers and Miners constructed all the bridges and culverts on the southern section as far as Qalat Saleh. The whole road was reported open on 25th April, although the last section of a couple of miles had to be completed under great difficulties, all the ground being flooded, and earth to make the embankment having to be brought by boat for a distance of three or four miles.

On the completion of this section of the road a few working parties were put on the road between Amara and Ali Gharbi, 69 miles in

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length, and a track was opened, passable by wheeled traffic, but not by motors. At the same time a reconnaissance between Ali Gharbi and Sheikh Saad (29 miles) was carried out by the Field Troop, 2nd S. and M., and showed that the road could be extended to that place without much difficulty.

At the end of May, 1916, the road from Kurna to Sheikh Saad, a total distance of 232 miles, was placed in charge of an A.D.W. for construction and maintenance. North of Amara the chief difficulty encountered was the presence of innumerable irrigation channels running at right angles to the river, used by the Arabs to carry the flood water from the Tigris to irrigate the lower land a mile or two from the river bank. These cuts were from three to five feet deep and eight to ten feet wide, and three to four hundred of them had to be bridged between Amara and Sheikh Saad. During the period of low water they were dry, and the road was taken through them as a temporary measure by ramping the sides. For the permanent road, however, corrugated iron culverts, or small timber bridges had to be installed. In June, 1916, a working party of 500 Pioneers was asked for, and the road could then have been completed in 60 days, but no troops were available, and as the local Arabs would not work during the Ramzan, the construction of the road was somewhat delayed. Transport for distributing material was also very scanty, and faced by these difficulties the life of the A.D.W., Tigris Road, was not a happy one. In August, 300 pioneers were allotted, and by the end of September, 1916, a road suitable for light motor traffic was open from Amara to Sheikh Saad. Meanwhile a railway was under construction from Kurna to Amara, and many portions of the raised road between Kurna and Qalat Saleh were utilized as the railway embankment, thus effectively destroying the communication by road during the floods. A low level road was demarcated, which was passable until the floods rose in the following March.

Between Busra and Kurna several large bridges were required, the most important one being at Gurmat Ali across a branch of the Euphrates. Here the river is 200 yards wide, very deep and tidal, the marshes a few miles inland acting as a huge reservoir, so that with the rise and fall of the tide in the Tigris a swift current flows either up or down the river. There were available at Busra some double cylindrical dredger pontoons, each cylinder being five feet in diameter and about 24 feet long. Lattice girders were ordered from India to take a load of 11 tons over a 30-ft. span, and with these the Euphrates was bridged, by the Tehri Garhwal Imperial Service Sappers, in August and September, 1916. At Shafi and Kurna boat bridges were constructed, and the other nullahs were spanned by trestle bridges. Thus direct communication by road was established between Busra and Sheikh Saad, a distance of 272 miles.

After the advance to Baghdad the extent of road became too great

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to be administered by one A.D.W., and the road was placed in charge of the A.D.W.'s Magil, Kurna, Amara, Kut, and Baghdad, each being responsible for the section of road in his district.

On the completion of the railway from Busra to Kurna the railway bridges over the Euphrates at Gurmat Ali and Kurna were used for the road, and later a temporary railway bridge over the Shafi Nullah was handed over as a road bridge. The former Gurmat Ali road bridge was dismantled and sent to Baghdad for re-erection.

Early in 1917 instructions were received to make all road bridges strong enough to carry $4\frac{1}{2}$-ton axle loads, and, as labour permitted, to construct a road which would be passable during flood time throughout. This entailed a great deal of earthwork, especially between Busra and Qalat Saleh, which was still progressing at the end of 1918.

Towards the end of 1917 a fleet of refrigeration barges was sent out from England to carry frozen meat, and it was decided that these should be placed under the Works Directorate, in order that ice and cold storage should be under one control. The fleet consisted of 13 barges, and each had on board a four-ton Lighfoot ice-plant, with two refrigerated holds. Capt. K. Lightfoot, R.E., was in charge, and he and his staff worked so successfully that they never lost a cargo.

Before the construction of the Busra cold store, the medical authorities found it impossible to keep vaccines in the country during the hot weather. The Busra ice-store included a compartment for the storage of vaccines, and when the refrigeration fleet was put in commission, the vaccines were carried up country cooled in the barges.

The lower part of Mesopotamia is practically devoid of all natural products useful in the building trades, and all materials except bricks have to be imported. The soil of the country makes fair bricks, but the supply of these has usually been short of the demands, owing to the difficulty in obtaining fuel for the kilns. Experiments have been tried in using oil-fuel and satisfactory methods have been brought into use.

After the capture of Hit a small quantity of bitumen became available for water-proofing roofs of houses and billets, and for repairing pontoons. The Turks used it for covering several of the roads in Baghdad, but, with the increase in horsed and motor traffic after the British occupation, it was not found suitable for a road surface, and none has been used in this way by the British.

In November, 1917, the Directorate suffered a great loss in the death at Baghdad of Brig.-General E. R. B. Stokes-Roberts, C.B. His place was taken by Brig.-General C. H. Roe, C.I.E., who was invalided in January, 1919, when his place was filled by Brig.-General A. J. H. Swiney, C.B., C.M.G.

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CORRESPONDENCE.

HOUPLINES RAILWAY BRIDGE.

To the Editor of the R.E. JOURNAL.

SIR,

May I be allowed to supplement the last paragraph of Major Sinauer's account of the repair of the Houplines Railway Bridge, given in the *R.E. Journal* for September, 1919, by a few further notes as to its later history?

The bridge was very badly damaged by the German bombardment of June and July, 1917. Though it had not then fallen, the number of large shell holes, particularly at or near important joints, was so great as to make further repair out of the question in the event of the Passchendael operations resulting in its being required for use in a hurry. Further bombardment might at any moment result in the wrecked span falling into the river again. If this had occurred we should have been faced with a long and difficult job, as was already proved by experience elsewhere, in removing the wreckage before being able to construct a temporary bridge. The high bank and marshy ground on either side, as well as the proximity of Houplines station rendered the rapid construction of a deviation impracticable. Fortunately a solution of the difficulty was presented by the fact that the abutments as shown in Major Sinauer's drawings were built for a double line, though the bank and bridge were only suitable for a single line. If, therefore, the damaged bridge could be moved on to the other unoccupied half of the abutment it would be out of the way of future work, whether it fell or not. The proposal to move it in this way was agreed to, and the work was carried out in the autumn of 1917 by a detachment of the 109th Rly. Co., R.E., under the direct supervision of Capt. (afterwards Major) E. Lyall, D.S.O., R.E. The conditions as regards hostile observation and shell-fire were then if anything worse than in 1915, and so much damage had been done to the roads and railway tracks in the neighbourhood that the necessary gear could only be brought to the Western outskirts of Armentières by lorry and taken forward from there by hand. The girders were jacked up sufficiently to allow of greased rails being inserted under them across each abutment, and the whole span was pushed sideways by horizontal jacks. The enemy fortunately, failed to notice that anything unusual was being done.

I never saw the bridge again after this was done, and should be interested to know whether the anticipation that the wreckage of it would fall sufficiently far to one side as not to hinder the construction of a temporary bridge practically on the old centre line, turned out to be correct.

Yours faithfully,

E. P. ANDERSON, *Major, R.E.*

Simla, 28th September, 1919.

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Lieut.-Colonel Sir Henry Trotter, K.C.M.G., C.B.

From a Photograph by Elliott & Fry, Ltd.

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MEMOIR.

LT.-COL. SIR HENRY TROTTER, K.C.M.G., C.B.

I FIRST knew Henry Trotter at Addiscombe College where, in the year 1859, he was already an old cadet whilst I was but a last joined member of the College and recognized, together with the Company that joined with me, as a "Green." Between the "Old Cadets" and the "Greens" there was but little intimacy. The special privileges accorded to them placed the old cadet on an upper shelf that was beyond the reach of the Green, and thus set a definite space between Trotter and myself which was not bridged over before he obtained his commission in the Bengal Engineers. I did not even know his name. Naturally, in days that were pervaded by the romances of Dickens he was known as "Job." When in due time I obtained my commission I found to my bitter disappointment that no more commissions in the Bengal Engineers were to be given to "nominated" cadets, and that I must serve my time afresh at Woolwich as a "competitive" if I aspired to join the Engineer Service. So it was three years before I met Trotter again, and then I found him in India doing excellent work in the Survey Department to which I was myself posted. The great trigonometrical branch of that department was then spreading out its network of scientific measurements from India to India's Hinterland in the Himalayas and beyond. Such men as Walker, Montgomerie, Herschell, and Bassevi (all Engineers) were building up the great skeleton which was to be the foundation of future map-making in Asia. It was in such good company that Trotter first commenced his scientific career. For 13 years he enjoyed the supreme satisfaction of adding year by year to our very immature knowledge of the geography of Northern India, and then occurred his great opportunity. The mission of Sir Douglas Forsyth to Yarkand in 1873-74 was a plunge into the regions of unmapped and almost unknown Central Asia. Trotter was appointed to the mission as Geographer and it was his success in mapping those remote Khanates, and in unravelling the skein of much confused geographical record of preceding times, that made his reputation and earned him the gold medal of the Geographical Society. At that time certain tentative efforts to secure trustworthy geographical mapping of the Oxus regions had already been made by Montgomerie, who had trained native explorers for the purpose.

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Trotter improved on Montgomerie's methods, and from that time forward the employment of natives in the field of geographical discovery has been uninterrupted and extraordinarily successful. But Trotter had always a hankering after diplomatic service, and he exerted himself successfully to exchange Indian experiences for those of diplomacy in the nearer East. After special service in China in 1876 he was appointed Assistant Military Attaché at Constantinople during the Russo-Turkish War of 77—78. He saw some wild service in Asia during the campaign, where he was present at the Seige of Kars and the Battles of Yeshek, Ilias, and other engagements. After this he became Consul in Kurdistan and after superintending relief operations at Scio following the great earthquake he once again was appointed to Constantinople as Military Attaché. He was Consul-General in Syria for four years, subsequently *Chargé d'affaires* at Bucharest and finally Consul-General in Rumania from 1894-96, and Delegate on the Danube Commission. Thus Colonel Trotter acquired a very wide knowledge of Eastern affairs which has been found most useful since his retirement both to Government and to The Royal Geographical Society which had always been an object of almost affectionate interest to him. He served on the Council of that Society for some years, and at the time of his death after a long illness (which he bore with great resignation and patience) he was Chairman of the Council of the Central Asian Society. I believe that Trotter had few really intimate friends. Always courteous, and rather reserved in manner, he was universally popular, but I never heard that he gave his entire confidence to anyone. Personally I knew him to have been a loyal and devoted friend, one who was utterly trustworthy and sound. As a young man he was a sportsman with something of a record: I believe he was the first European to shoot Ovis Poli in the Pamirs, and I know that he was one of a very few who have shot lions in Gujrát. His adventures in the field of Indian sport were many and varied, though he never spoke of them. I am aware, however, that on one occasion a very angry tiger was heaved by an angry elephant over the Mahout's head into Trotter's howdah, alongside of him, and this I think an incident unusual even in tiger annals. Taking it altogether, few men have lived more strenuous and adventurous lives than Colonel Sir Henry Trotter. He was one of the last links connecting that splendid old service, The East India Company's Engineers, with the modern Imperial List, and with his peaceful passing away we can almost count the few that remain on the fingers of one hand.

T. HOLDICH.

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REVIEWS.

REINFORCED CONCRETE CONSTRUCTION.

By HENRY ADAMS, M. INST. C.E., M.I. MECH. E., F.S.I., F.R. SAN. I., etc., and ERNEST R. MATTHEWS (Captain R.A.M.C.). A.M. INST. C.E., F.R.S., (ED.), F.R. SAN. I., F.G.S.

The authors deal very little with the theory of Reinforced Concrete Construction and make no attempt to demonstrate the formulæ that they use, but the book contains a large number of excellent photographs which are very suggestive of the uses that can be made of Reinforced Concrete. Many detailed drawings are also reproduced, the value of which would be even greater were they more fully dimensioned.

H. L. LEWIS, *Lt.-Col., R.E.*

THE VITAL CHOICE: ENDOR OR CALVARY.

A Reply to Sir A. Conan Doyle's *The New Revelation*, by Lt.-Col. D. FORSTER, C.B.E., D.S.O., R.E. (Morgan and Scott). 2/-

Colonel Forster states clearly and concisely the case of the impiety of modern Spiritualism. The genuineness of the manifestations is not disputed, but the view that the very specific opposition of the Old Revelation to magic and sorcery may in these latter days be disregarded is opposed by arguments which merit serious consideration.

YPRES, 1914.

An Official account published by Order of the German General Staff. Translation by G.C.W. (Constable and Co., Ltd.), 5s.

This is the translation of the book "Die Schlacht an der Yser und bei Ypres" which was announced as in course of preparation by Brig.-General J. E. Edmonds in his article, "Some Books on the War" (*R.E.J.* September, 1919, p. 129), and is advertised in *The Times Literary Supplement*, under the title of "The Battle of the Yser and of Ypres, 1914." The translation, with its introduction and abundant notes by the Historical Section (Military Branch) Committee of Imperial Defence, gives, in a compact form and with great clearness, the truth, "as far as it has yet been officially revealed" of the great battle which Lord French describes as "more momentous and fateful than any other" that he directed during the period of his command in the field.

F.E.G.S.

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NOTICES OF MAGAZINES.

THE MILITAR-WOCHENBLATT.

September, 1919.

Articles by our friends Generals von Bernhardi and Balck give the numbers quite a pre-war flavour. There are particularly interesting articles on the bridging of the Marne at the second battle in 1918, and on the operations of Field Marshal French against the German First Army, in which some Supreme Command operation orders are given.

No. 28.

Sir Douglas Haig's Dispatch.—Translation of the Dispatch of 10th April, 1919.

Survey of the Events on the Russian Battle-fronts, 20th July—15th August, 1919.—The writer considers that signs of the impending fall of Lenin and Co. are increasing: peasant risings, hunger revolts, street fighting and conspiracies in the large towns, all indicate that the feeling against Bolshevism is rising fast. Privations in the coming winter will be severe and will ring the knell.

Regimental Unions.—The list of these, continued from No. 20, shows a total of 42.

Rolls of Honour.—Field Artillery Regiment No. 61: officers killed in 1914, 7; 1915, 1; 1916, 10; 1917, 12; 1918, 18. Infantry Regiment No. 140: 105 officers and about 5,000 other ranks killed. Mounted Jäger Regiment No. 4: 16 officers killed.

No. 29.

On the Infantry Attack.—By Lieut.-General Balck. This well-known writer re-appears. His article, with examples from the Bulgarian-Turkish war and an attack of the XI. German Corps on 8th September, 1914, at Barten, seems to aim at showing that German methods were right and French wrong. The striving for fire superiority, advance by rushes, covering fire, which he praises, were practised by the British Army before the war; General Balck, though he was a recognized authority on the British Army, does not, however, refer to this.

Preventive War.—By General von Bernhardi. This well-known writer re-appears in print to defend himself from press attacks for having advocated preventive war, that is knocking down likely adversaries before they are too strong. His defence is that Frederick the Great practised it and that all would have gone well if the Germans had won the battle of the Marne. He adds that although Bismarck in his "Gedanken und Erinnerungen," deprecated it, he was old when he penned the book, and when young, 1866 and 1870, himself engineered preventive wars. A thoroughly cynical and genuinely Prussian article.

Sir Douglas Haig's Dispatch.—Continuation of the translation.

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Rolls of Honour.—Field Artillery Regiment No. 50: 26 officers and 339 other ranks killed. Guard Foot Artillery Regiment: 84 officers killed. The Colonel signs the roll as "the last commandant."

No. 30.

Denmark and the League of Nations.—A complaint that whilst the German Army is being reduced to a police force, the Danes, without hindrance from the League of Nations, are increasing their forces.

Charges against the Governor of Maubeuge, General Fournier.—In view of the charges of treason made against the General who surrendered Maubeuge in September, 1914, General von Zwehl, who commanded the investing force, gives certain particulars. He states that Maubeuge was originally invested by the 14th Reserve Division (less two battalions), with six field batteries and 80 heavy guns, and a reinforced infantry brigade (the 26th of the 13th Division), with three field batteries. 13th Reserve Division arrived on the 1st September only. The French garrison, as is known, consisted of one regular infantry regiment, the rest of the 43,000 being made up of reservists and territorials. The original plan had been for parts of the IX. and VII. Corps to attack Maubeuge, but they had been hurried on past it. General von Zwehl states that the surrender was due to bombardment by heavy guns. Forts Brussois and des Sarli were badly damaged. Bersillies and Salemangne had badly suffered. The well constructed defences between the forts were "quite undestroyed." He adds that as the troops marched out they saluted General Fournier respectfully. He ends by saying that Fournier should not be blamed for a defeat by the Germans as the French and English could not have won the war without American help.

The End of the Imperial War Museum.—The project for this museum has been abandoned.

Sir Douglas Haig's Dispatch.—Translation continued.

Cadet Establishments.—Six are to continue in existence: Köslin, Karlsruhe, Naumburg, Plön, Potsdam, Wahlstatt.

Rolls of Honour.—Pioneer Battalion No. 23: 46 officers, 137 N.C.O.'s and 1,194 men killed, 2 officers missing. Pioneer Battalion No. 1: 35 officers, 160 N.C.O.'s and 1,049 men killed, 2 officers missing. Infantry Regiment No. 31: 95 officers, 1,647 other ranks killed.

Advertisements.—Conversion of uniform into civil clothes. "Officer's cape makes a complete suit; officer's greatcoat, coat and waistcoat or overcoat; tunic and jacket make elegant sport jackets; frock coat makes evening coat," etc.

No. 31.

England's Imperial Air Programme.—A summary of information as to the state and organization of our air forces.

Kriegervereine and Officers.—These associations of old soldiers which have existed since 1871, will in future admit officers as ordinary members without the special privileges of rank and station they formerly enjoyed.

Sir Douglas Haig's Dispatch.—Continuation of translation.

Rolls of Honour.—Infantry Regiment No. 68: 125 officers and 2,355 other ranks killed.

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No. 32.

The Technical Instruction of Artillery Officers.—The article brings to notice a paper written by the well-known Lieut.-General Rohne, in which he states that the German Field Artillery was without doubt inferior to that of the French, not only in equipment, but instruction. In Germany the instruction of the officers was neglected. It is suggested (1) that only young men with good mathematical knowledge should be accepted as officer candidates; (2) that every artillery officer should receive a thorough technical scientific training; (3) that specially qualified officers should receive further instruction; (4) that officers who do exceptionally good technical work should receive the same promotion privileges as the former General Staff; (5) that the Artillery Committee should be provided with a scientific section, and (6) that scientific literature should be made available for officers.

The English Campaign in Mesopotamia in the Autumn of 1918.—A translation of General Marshall's dispatch, which is continued in the following number.

Removal of the Private Property of Members of the Army from Alsace-Lorraine.—Nothing has apparently been done to send this property back to Germany yet, and the complaints are loud.

The Gazette contains a number of steps in rank without pay.

Rolls of Honour.—Pioneer Battalion No. 2: 35 officers and 1,171 other ranks killed. Infantry Regiment No. 42: 98 officers and 2,985 other ranks killed. Infantry Regiment No. 26: 144 officers and 2,921 other ranks killed.

No. 33.

The Russian Soviet Armies.—There are about half a million men in arms in 15 armies: about 45,000 on the north and west front, 170,000 on the west front, 170,000 on the southern front and 135,000 on the east front. In the interior are 725,000 men more. Mass desertion is rife; the results of mobilization of all men under 40 have been poor. The spirit of *Nitchevo* and *Avos* ("it doesn't matter" and "perhaps it will be all right") prevail; even a Red Army cannot be efficient without sense of duty and discipline, and these are lacking. It is wonderful how a Government supported by such an army can go on.

Compensation for Increased Cost of Living.—Civil officials are receiving this, but officers are not.

Rolls of Honour.—Foot Artillery Regiment No. 27: 17 officers and 385 other ranks killed. Infantry Regiment No. 91: 128 officers and about 4,000 other ranks killed.

No. 34.

The Military—Political Situation in Russia in the latter half of August, 1919.—It is considered evident that the Bolshevists are getting the worst of the fighting everywhere.

The Pioneers on the Marne in July, 1918.—A most interesting article, giving an account of the engineer operations in the successful bridging of the Marne in the last German offensive, which deserves translation. The river, 240 feet wide, presented no special obstacle, but as the slope

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down to it commenced 3,000 to 4,000 yards away and was in full view of the enemy, the pontoons had to be carried down by night and hidden in holes, trenches, etc., and camouflaged. A company could only carry down four pontoons a night. Everything was carefully rehearsed for several weeks, the reconnaissances were not commenced until 14 days before the passage. It was planned that every division should have (a) a pioneer battalion with a Corps bridging team for the ferries; (b) two pioneer companies with five divisional bridging trains for the bridges; (c) three pioneer companies for engineer duties on the far side of the Marne; (d) one pioneer company in reserve. Owing to lack of material and an influenza epidemic, this ideal was not reached.—(*To be continued*).

The Danger of German Aviation.—The writer quotes with some glee the fears expressed in French newspapers that Germans will build a commercial fleet of aircraft easily convertible into fighting machines.

Roll of Honour.—Guard Grenadier Regiment No. 2: 133 officers and over 4,500 other ranks killed.

No 35

The Operations of Field Marshal French against the First Army and the VII. Reserve Corps in the Summer of 1914.—By General von Zwehl (Commander of the VII. Corps). This is a fairly sharp criticism of Lord French's book, which has been translated in the columns of the *M.W.B.* It is described as a medley of operation orders, wishes and anxieties with excursions into unimportant side issues, the activities of small units, even of patrols. What the German General cannot understand is what he thinks is the Field Marshal's evident ignorance of things German, his extraordinary bad taste in bestowing praise and blame on living officers, and his unprovoked attack on General Lanrezac. It is astonishing he says, that a man of Lord French's reputation should write so unscientifically and confusedly. England, as regards writing military history is evidently still in its "child's shoes"

The History of Tanks in England.—A summary from the English papers. (It is remarkable how much is taken from English sources in the present day *M.W.B.*, it ignored us before the war).

The Pioneers on the Marne in July, 1919 (continued).—Details of the construction of the bridges are given. As is well known, the Americans put down a barrage 10 minutes before the German zero, at 1 a.m. on the 14th; the men carrying down the pontoons had to put on their gas masks, with results that may be imagined on a pitch dark night, and when they reached the water's edge, they came under M.G. fire; nevertheless, of the 130 pontoons to ferry over the first advanced parties, 108 were got into the water. Eventually it was only possible in some divisions to make one bridge instead of two; that of the 10th Division was sunk, that of the 36th Division was not completed until evening; the 23rd Division made two, but one was sunk by a direct hit; the 200th Division made two, but one was destroyed and replaced by a foot trestle bridge: the Guard Infantry Division made two bridges, as did the 37th Division, but the second was only completed at 11.30 p.m. on the 15th; the 113th Division did much the same.

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When the Germans recrossed the river in retreat, of the original six corps and 29 divisional bridging trains enough was rescued to make 1½ corps and three divisional ones. Thus ended the activity of the German Pioneers on this "bad luck river," as the article calls it. The total losses of the 59 Pioneer Companies are not given, but the 28 G.H.Q. Companies lost : killed, eight officers, 157 men ; wounded 28 officers, 783 men ; missing, one officer, 52 men. A fine performance of the German Pioneers.

Rolls of Honour.—Field Artillery Regiment No. 31 : 19 officers and 200 other ranks killed. Railway Troops : 120 officers killed, or died in consequence of hardships. Jäger Battalion (Hanover) No. 10 : 111 officers, and 2,924 other ranks killed (these figures for a battalion are the heaviest infantry losses yet noticed).

No. 36.

The Operations of Field Marshal French (continued from No. 35).—A most interesting number. The German difficulties on account of not knowing when the English would appear and the actual surprise of their appearance at Mons are brought out. The following Supreme Command orders quoted are of importance.

"28th August, 1914.

"The First Army, with the II. Cavalry Corps, will march towards the Lower Seine, west of the Oise. It must be ready to co-operate should the Second Army become engaged. It will deal with any hostile new formations in its area.

"The Second Army, with the I. Cavalry Corps, will advance *viâ* the line La Fère-Laon on Paris.

* * * * * * * *

"Should the enemy offer determined resistance, on the Aisne and subsequently on the Marne, the direction of the Armies may be changed from south-west to south."

"3rd September.

"The intention of the Supreme Command is to drive the French in a S.E. direction away from Paris. The First Army will follow echelonned in rear of the Second Army, and will be responsible for the flank protection of the Armies."

Mouvement Tourné.—An article dealing, *apropos* of the battle of the Ourcq, with the turning of the flank of a turning force. The battle of the Lisaine, January, 1871, is discussed to show that von Werder used these tactics then.

The Peace Treaty and German Flying.—This points out Germany's favourable central position in Europe for air communication.

Rolls of Honour.—Infantry Regiment No. 172 : 137 officers and over 3,000 other ranks killed. Reserve Infantry Regiment No. 220 : 76 officers and over 2,500 other ranks killed. Pioneer Battalion No. 29 : 24 officers and 1,070 other ranks killed.

No. 37.

The Officers' Compensation Law.—The text of the law as passed by the Reichstag and promulgated is given. Officers under five years'

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service who are compulsorily retired receive a year's pay; between five and eight years' service, two years' pay; between eight and ten service, three years' pay. Officers with over ten years' service receive the pension that they would have been entitled to if found unfit for further service.

The French Colonial and North African Army.—Extracted from *The Times* of 6th September, 1919.

The Operations of Field Marshal French (continued from No. 36). This deals with the battle of the Marne, and only brings out that von Kluck strongly opposed the retirement to the Aisne, when the order was brought to him by a special representative of the Supreme Command.

Roll of Honour.—Foot Artillery Regiment No. 3: 95 officers killed.

No. 38.

The World Military-Political Situation.—Contrasts our reduction of the Army of the Rhine with Marshal Foch's demands for more troops, and gleefully sketches our entanglements in Russia, Egypt, and elsewhere.

The Operations of Field Marshal French (continued from No. 37).—Deals with the battle of the Aisne, in which the writer's Corps took a distinguished part. On the 13th September, 8 a.m., the heads of its two divisions were about 10 miles S.E. of Laon. It then received orders to support the left of the First Army. No sooner had this movement been got under way than the Second Army ordered the corps to come to its support *viâ* Berry au Bac. General Zwehl stuck to his original orders unfortunately for us. The articles end with a paragraph insisting that the retirement from the Marne was a "voluntary one."

The Economic Position of Officers.—A long article about the recovery of officers' furniture left in Alsace-Lorraine.

Rolls of Honour.—Foot Artillery Regiment No. 59: 36 officers and 501 other ranks killed. 11 officers died of illness contracted in the field. Infantry Regiment No. 57: 142 officers and 5,100 other ranks killed on the west front. Infantry Regiment No. 118: 118 officers and 2,900 ranks killed, four officers missing.

J. E. EDMONDS.

REVUE MILITAIRE SUISSE.

No. 9.—September, 1919.

THE GERMAN AND FRENCH CAVALRIES IN THE GREAT WAR.

The article on the above subject by Colonel Poudret begun in the March number of the *Revue* (*vide R.E. Journal* for June, 1919, *et seq.*) is continued in the number of the publication under notice.

The author of the original article devotes attention to the work carried out by *cavalry patrols*. He points out that for a quarter of a century and more the much vaunted work of the German cavalry patrols in 1870 has been constantly paraded for the edification of cavalrymen. The circumstances under which the German cavalry had to operate in the year mentioned were vastly different to the conditions prevailing in 1914. In 1870, the German patrols had little to fear from the French

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Cavalry; their security services were nevertheless badly carried out, they were frequently surprised and often lost contact with the opposing forces.

It is for want of better examples, and for no other reason, that the work of the German patrols, including that of the famous Zeppelin patrol, has been so constantly brought before students of military history during the past four decades, in spite of the fact that practically every conceivable mistake which could have been committed was actually made by the German patrol leaders.

From the outset of the campaign in 1914, it was realized that, with the short distance separating the contending armies, it would only be in rare circumstances that cavalry reconnaissances could result in procuring intelligence concerning the enemy without serious fighting. Consequently reconnaissances were made in great force, and even then the difficulties encountered were immense. The results obtained, although considered very satisfactory, were secured at a great price, having in view the casualties suffered. The intelligence collected in Belgium by Sordet's cavalry and the provisional cavalry division in the critical days of August and September, 1914, was particularly accurate, abundant and more important than is generally recognized to have been the case.

Colonel Poudret gives short accounts, in the original article, of the work done during the last year of the war by many of the patrols sent out by the divisional cavalry. Much of this work proved of immense value to the French troops. In one case, the intelligence collected by the patrols of the divisional cavalry was so complete, it is said, that *the infantry was not once ambushed, nor did it make a single useless march*, but was able to make all necessary dispositions betimes in order to meet the enemy's moves and to provide for its own security. Further, the long turns of dismounted duty during the four years of trench warfare, largely on the defensive, exercised no adverse influence on the keenness of the French Cavalry when again employed as a mounted arm in its normal sphere of activity.

The war has cleared away many erroneous doctrines; the ruins of the delusions having been swept away, it has been possible to build up, on a solid foundation, proper conceptions relating to the sphere of utility of cavalry. Colonel Poudret tells us that the lessons of the war indicate that the field of action for cavalry is comprised under the following heads:—

1. It must reach the important defensive positions betimes and hold on to them tenaciously until the infantry can arrive to take over the defence; that is to say, its function is to gain time.

2. It must at once fill or close up any breaches or gaps made in the front on which its own side is fighting.

3. It must mask the withdrawal of troops from the fighting line.

4. It must move quickly as reinforcements to a threatened point on a distant part of the far-flung battle front.

5. It must exploit the success gained by its own infantry by passing through the breach made for it in the enemy's front.

6. It must act against the enemy's lines of communication by turning one of the enemy's flanks.

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The cavalry should, says Colonel Poudret, be always held in *reserve* as near the battle front as possible so that it may be thrown into the fighting line as early as possible. From the earliest days of the war, the necessity was realized of having troops, more mobile than infantry, readily available for the purpose of rapidly reinforcing threatened points and the parts of the front temporarily uncovered.

So long as necessities of this kind are likely to occur cavalry will always have a sphere of action on a modern battlefield.

Comments are made in the original article on the French Regulations most recently issued. It is pointed out that although the Swiss Army cannot expect to be provided with tanks, heavy batteries, Q.F. guns, and the other technical appliances with which modern armies are endowed, nevertheless its weak cavalry brigades should have an increase in the numbers of machine-guns allotted, and should be issued with automatic rifles. Further, in view of the importance of *liaison*, it is suggested that a better provision should be made in the matter of motor-cars, motor-cycles, field telephones, wireless telegraphy, etc.

It is pointed out also that a study of the French Regulations shows that the methods of training in vogue in the Swiss Army require to be thoroughly revised and brought up to date.

The original article concludes with a copy of a document issued by Marshal Pétain on 3rd August, 1919, entitled: *Note pour les armées au sujet de l'instruction dans les corps de troupe de cavalerie.* This Note lays down the *Principles for the Employment of Cavalry*, and discusses the *Conditions under which it is to be employed*; *The Cavalry of the Future*; and *The Methods and Means of Training.*

Permanent Fortifications in the Great War.

The article on the above subject begun in the number of the *Revue* for July last (*vide R.E. Journal* for October, 1919) is continued in the number under notice.

The defence of Antwerp (September 28th to October 10th, 1914) is considered. A brief description of this famous fortress is given: it comprised three successive lines of defence:—

(*a*) The old ramparts of the town remodelled in 1860 by Brialmont;

(*b*) The inner line of 14 forts, with intermediate works, on a circumference measuring about 28 miles, constructed by Brialmont in 1860. These forts were from 2½ to 3 miles from the town, and their armament was similar to that in the forts round Liege and Namur.

(*c*) The outer line, at an average distance of nine miles from the town, consisting of 19 forts on a circumference measuring about 62 miles. The construction of these defences was begun in 1890. Of the guns and mortars forming the armament of these forts, none of the former exceeded a calibre of 15cm. and none of the latter exceeded 21cm. in calibre.

The events connected with the retirement of the Belgian Army into Antwerp are briefly stated in the original article. Between the 25th August and 27th September, the Belgians made three sorties against the German line of communications, but, in view of the superior forces brought against them they had to retire within the protecting works of the great retrenched camp of which so much had been expected.

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The besieging army was commanded by General von Beseler, the German Inspector-General of Fortifications, who had played a similar *rôle* at Liege, Namur, and Maubeuge. His command consisted of the Third Reserve Corps, the 26th and 37th Landwehr Brigades, a Division of Fusilier Marines, the 1st and 4th Ersatz Divisions, a Bavarian Division, a Garrison Artillery Brigade, and a Brigade of Siege Pioneers, totalling approximately 150,000 men. Fearing operations against their lines of communication, the German siege artillery having been liberated by the fall of Maubeuge, the Great General Staff decided to make a concentrated effort to capture Antwerp. The principal attack was directed against the 3rd sector—the front between the Dyle and the Petit Nithe; whilst a feint was arranged for on the 4th sector—the front between the Dyle and the Scheldt.

On the 28th September, the siege commenced with an attack on the forts known as Waelhem and Wavre-St. Catherine; 10 shots a minute were fired against the former.

On the 29th September, the attack against the 4th sector was begun, but produced no immediate result. At the same time the attack against the 3rd sector was intensified. The destruction, by an explosion, of the magazine at Fort Wavre-St. Catherine compelled the garrison to evacuate it after a defence of 18 hours; the moral effect of this was disastrous, as it destroyed the confidence of the Belgian troops in their great stronghold. Measures were at once taken to create a base at Ostend, and the withdrawal was begun from Antwerp without delay. During eight nights convoys passed westward over the Scheldt by a single bridge at Tamise, in doing so passing within three miles of the German lines; the fortifications, at least, enabled the supplies accummulated at Antwerp to be withdrawn.

The forts in the 3rd sector became untenable on the 2nd October and had to be evacuated. Two days later the British Naval Brigade, 2,200 men strong, arrived in Antwerp, and on the same day the Germans crossed the Nithe and forced the passage of the Dendre; the enemy was now in rear of the Belgian first line of defence. By the 6th October, the breach in the 3rd sector had been widened and formed a gap measuring some 12½ miles of front. The Belgian Army began to retire on Ostend during the night of 6th-7th October. For the defence of the citadel there now remained the garrison of the forts, the Belgian 2nd Division, three British Naval Brigades and a few regiments of fortress infantry.

On the 7th *idem*, the attack on the inner line of forts was begun and at midnight the town itself was bombarded. Two days later, a few Germans penetrated into the town, after capturing some of the inner forts. On the 10th *idem*, the fortress capitulated, after all the troops had evacuated the town: 30,000 men, who had defended Antwerp, crossed into Holland and were interned.

The Germans fired approximately 300,000 projectiles—weighing more than 30,000 tons in all—against Antwerp and its defences. It took 100 trains of 30 wagons each to transport this ammunition to the besieging force, whilst 100 additional trains were needed for bringing up other stores, etc. About 200 trains were required for the siege artillery, which required a powerful army to support it. This then is a

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measure of the *effort* expended by the Germans in the capture of Antwerp.

Although Antwerp only held out for 12 days, after the siege was begun, it played a most useful purpose in the days from the 4th August to 28th September preceding the German onslaught. In order properly to appreciate the value of permanent fortifications the whole of the circumstances must be taken into account. The fortress of Antwerp fully justified, as events show, all the expenditure that had been incurred in bringing it into existence.

The defence of Verdun is touched upon. During the epic days, at the beginning of 1916, the works here played only a passive *rôle*. It was the garrison artillery and the troops which were responsible for the hard times that the Germans had to face. Owing to a hasty decision, forts were either lacking at Verdun, or, where forts existed, they were ill-found. Undoubtedly, permanent fortifications remain to-day, as they have always been, a most precious adjunct in defence, where care is taken to ensure that certain conditions are fulfilled in relation to them.—(*To be continued*).

Criteria of Physical Strength.

The original article is from the pen of Dr. F. E. Koby, a Surgeon-Lieutenant in the Swiss Army. He calls attention to an article contributed by him on "A New Measure of Physical Strength" to the *Revue* for April, 1919 (*vide R.E. Journal* for June, 1919). Dr. Koby alludes to the methods employed in evaluating numerically the "robusticity" of an individual, and briefly passes in review matters affecting the muscles, heart, and lungs. He mentions the use of the dynamometer in connection with the measurement of the physical strength of certain groups of muscles and the use of the ergograph for determining the fatigue curve of an individual. He points out that the methods of exploring the heart are numerous, but not reliable; pulsations of the heart can be counted, the beats of the pulse graphically recorded, arterial tension measured, etc. Nevertheless, the foregoing information does not enable the medical man to form a definitive judgment on the functional value of the heart, and only the nature of the reaction produced by muscular effort can provide a solution to the problem in question. The effect of physical exercise on cardiac acceleration is briefly reviewed.

Questions affecting respiration are next dealt with and also the methods employed to measure "pulmonary ventilation," that is to say, the total amount of air displaced during physical exercises extending over a definite period of time. A formula is obtained by Dr. Koby for what he terms the "pulmonary co-efficient," a factor which plays an important part in the determination of the "vital capacity" of an individual.

Notes and News.

Switzerland.—Colonel Sonderegger has taken over the duties of Chief of the Swiss General Staff. He has a difficult task before him. It is pointed out that the whole of the Swiss Army system requires overhauling; the administrative methods, the organization, the disposition, the

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methods of command. Some doubt appears to exist as to the capacity and willingness of the new Chief to carry through the necessary reforms.

The question of a successor to the *Revue Militaire Suisse* is discussed. It is stated that a Central Committee of the *Société des Officiers* is at the present time considering the matter of starting a new paper. The proposal is to publish a fortnightly bilingual journal of 16 pages. It would seem that the intention is to issue a journal devoted to social matters, but comprising two supplements containing articles of a scientific nature; one of them in French, with occasional articles in Italian, and the other in German. Should this project succeed, the *Revue* is likely to be absorbed in the new venture, since there is scarcely room in Switzerland for two first-class military journals.

INFORMATION.

Switzerland.—The difficulties which arose in connection with the training of the 1st Battalion of Carabiniers at Zurich during August last, owing to the applications for the exemption of men employed by municipal, cantonal, and federal authorities, and by commercial houses is referred to. The situation thus created amounted almost to a scandal.

Although the Regulations forbid men to take uniform and articles of equipment home with them on demobilization, little attention is paid to these regulations. It is pointed out that the practice which has recently come into vogue of men wearing uniform when engaged on civilian work is likely to add to the military budget, since military garments are thus being worn out prematurely. It is suggested that the inspection of arms, equipment, etc., which prevailed before the war, should be reinstituted as a check to secure observance of rules and regulations.

Bulletin Bibliographique.—Notices appear relating to two works:—*La guerre sur mer*, which is a translation of Rudyard Kipling's well-known volume, and *Les germes de la grande guerre*, a translation by M. Cuno Hofer of the German volume *Die Keime des grossen Krieges*.

W. A. J. O'MEARA.

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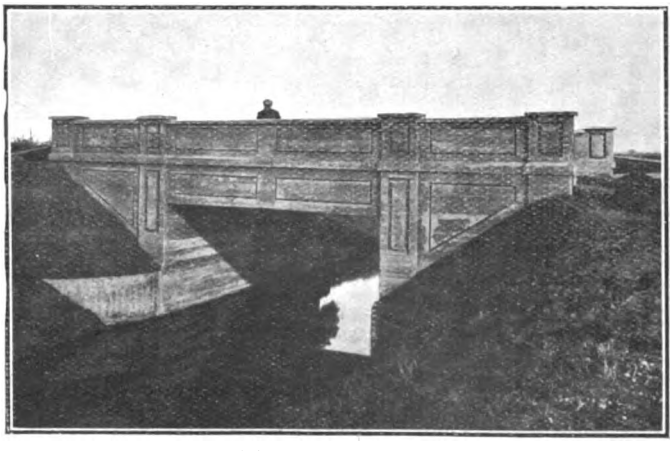

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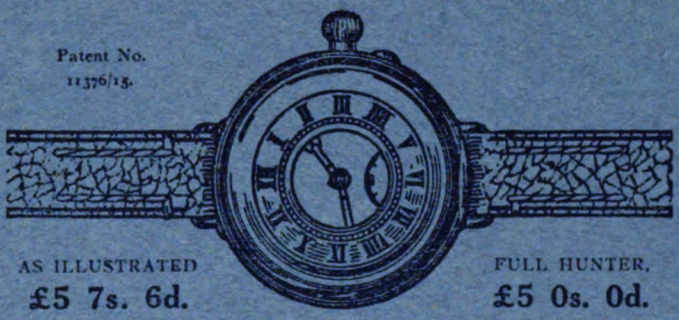

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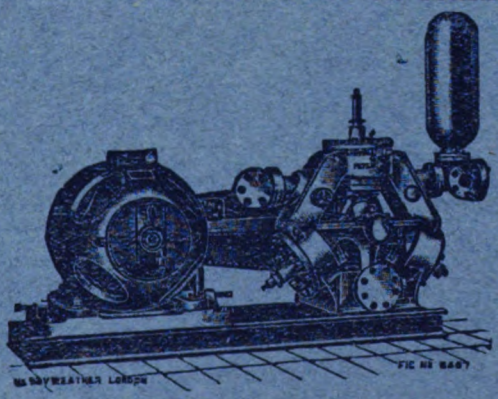

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